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THE LATE RICHARD WAGNER.

RICHARD WAGNER, the poet-composer, died at Venice on the 13th of February, 1883. He was born at Leipzig in 1813. This remarkable man has caused more acrimonious discussion in the world of music than any other composer, excepting Gluck, who was, however, far less innovating than the modern German celebrity. In endeavoring to revolutionize opera, and to free it from conventionalisms of which no one disputes the existence, Wagner has, as lawyers say, "proved too much," and his later works are, musically, little more than stilted declamation and recitative in which melody and coherent form and development are ignored. That he was a man of exceptional intellectual power none can doubt. This was proved by his opera books (all written by himself), and by many criticisms—literary and musical—much of his critical writing being characterized by a fierce bitterness that may have resulted from his early struggles for a success which he at length obtained, perhaps in an undue degree. We have so often dwelt critically on the characteristics of his productions, that no more need now be said on that head. His operas (all but his latest) have been produced on our stage, either in Italian, German, or (by Mr. Carl Rosa) in English; the most recent instance having been the performance of his series of four "Nibelungen" opera-dramas—"Das Rheingold," "Die Walküre," "Siegfried," and "Götterdammerung"—by a German company, at Her Majesty's Theater, in May last; his "Lohengrin," "Tannhäuser," "Der Fliegende Hollander," "Die Meistersinger," and "Tristan und Isolde" having been given by another German company at Drury Lane Theater about the same period. "Parsifal," his latest work—which followed the "Nibelungen" series—was brought out last summer, at the theater specially built for Wagner's productions at Bayreuth, where the "Nibelungen" operas were first given, in 1876. Only a very small portion of "Parsifal" has yet been heard—in concert room performance—in this country. His earlier works—"Rienzi" (1842); "Fliegende Hollander" (1843); "Tannhäuser" (1845); "Lohengrin" (1850); and "Die Meistersinger" (1868)—were comparatively free from the crude exaggerations which mostly characterize his other stage works.

Wagner was twice married, his second wife being a daughter of Liszt, who was the earliest promoter of the composer's success by his enthusiastic advocacy of Wagner's claims to rank as a great regenerator of dramatic music. The disastrous failure of Wagner's attempt to produce his "Tannhäuser" at Paris, and the continued opposition to his music in this country, have been followed by a widespread success (excepting in France) such as he, with all his self-confidence, could scarcely have expected to have been realized during his lifetime. Much of this success in Germany is certainly owing to the enthusiastic and liberal support given to Wagner by the King of Bavaria. Opposition there still is on the part of many competent critics to the exaggerations and forced eccentricities of his later works; but the most adverse of these authorities could but recognize in Wagner a man of rare intellectual power, musical and literary, and a sincere and earnest, though arrogant (and, in some respects, mistaken), reformer of the absurd conventionalisms which too frequently characterize the music of the operatic stage, more especially that of the modern Italian school. Had Wagner been endowed with a spontaneous creative musical genius in proportion to his other intellectual gifts, he would probably have stood higher in the estimation of distant posterity than he is now destined to do. He has, however, created an era in musical art that has become matter of imperishable history; and the tributes rendered to his memory from distant points of civilization afford ample proofs of his widespread influence. His didactic and critical writings comprise many volumes, and it is said he has left an autobiography, which cannot fail to be highly interesting.

The remains of the deceased composer were forwarded from Venice to Bayreuth for interment in the mausoleum which he prepared for himself some years ago, a public funeral having been arranged by the authorities. The obsequies took place with imposing ceremonials.—*Illustrated London News.*

RICHARD WAGNER.

JOHN HARRISON, THE CHRONOMETER MAKER.

By SAMUEL SMILES.

AT the Royal Observatory, Greenwich, one of the most remarkable instruments is to be seen—the first chronometer, the parent of a numerous progeny of chronometers, used on board of every sea-going ship, to the advantage of navigation, of commerce, as well as of science. As far back as the reign of Queen Anne, in the year 1714, the English Government offered the large prize of £20,000 to the person who should find the method of discovering the longitude at sea, within certain specified limits. The reward was offered to the world, to inventors and scientific men of all countries, without any restriction of nation, or race, or language. To the surprise of every one—it was thought remarkable, and it *was* remarkable—the prize was won by a man who had been brought up as a village carpenter, of no school, or college, or university. But the truth is that the great mechanic, like the poet, is born, not made; and John Harrison, the winner of the famous prize, was a born mechanic. He did not, however, accomplish his object without the exercise of the greatest skill, patience, and perseverance. Indeed, his life, so far as we can ascertain the facts of it, is one of the finest examples of difficulties overcome, and of undaunted perseverance eventually crowned by success, in the whole range of biography.

No complete narrative of Harrison's career was ever written. Only a short notice of him appears in the "Biographica Britannica," published in 1766, during his lifetime—the facts of which were obtained from himself. A few notices of him appear in the "Annual Register," also published during his lifetime. But no life of him has since appeared. Had he won battles by land and sea, we should have had biographies of him without end. But he pursued a more peaceful and industrious course. His discovery conferred an incalculable advantage on navigation, and enabled innumerable lives to be saved at sea; it also added to the domains of science by its more exact measurement of time. But his memory has been allowed to pass silently away, without any record being left for the benefit and advantage of those who have succeeded him. The following memoir includes nearly all that is known of the life and labors of John Harrison.

He was born at Foulby, in the parish of Wragby, near Pontefract, Yorkshire, in May, 1693. His father, Henry Harrison, was carpenter and joiner to Sir Rowland Wynne, owner of the Nostel Priory estate. The present house was built by the baronet on the site of the ancient priory. Henry Harrison was a sort of retainer of the family, and he long continued in their service.

Little is known of the boy's education. It was certainly of a very inferior description. Like George Stephenson, Harrison had always a great difficulty in making himself understood either by speech or writing. Indeed, every board-school boy receives a better education now than John Harrison did a hundred and eighty years ago. But education does not altogether come by reading and writing. The boy was possessed of vigorous natural abilities. He was especially attracted by every machine that moved *upon wheels.* The boy was thus "father to the man." When six years old, and lying sick of small-pox, a going watch was placed upon his pillow, which afforded him infinite delight.

When seven years old he was taken by his father to Barrow, near Barton-on-Humber, where Sir Rowland Wynne had another residence and estate. Henry Harrison was still acting as the baronet's carpenter and joiner. In course of time young Harrison joined his father in the workshop, and proved of great use to him. His opportunities for acquiring knowledge were still very few, but he applied his powers of observation and his workmanship to the things that were nearest him. He worked in wood, and to wood he first devoted his attention.

He was still fond of machines going upon wheels. He had enjoyed the sight of the big watch going upon brass wheels when he was a boy; but now that he was a workman in wood he proposed to make a time-keeper with wheels of that material. After many difficulties—and nothing can be accomplished without them—he succeeded in making a wooden clock, with wheels of wood. This, however, was only a beginning. He proceeded to make better clocks; and then he found it necessary to introduce metal, as being more lasting. He made pivots of brass, which move more conveniently in sockets of wood, with the use of oil. He also caused the teeth of his wheels to run against cylindrical rollers of wood, fixed by brass pins, at a proper distance from the axes of the pinions; and thus to a considerable extent he removed the inconveniences of friction.

In the meantime Harrison eagerly improved every incident from which he might derive further information. There was a clergyman who came every Sunday to the village to officiate in the neighborhood; and having heard of the sedulous application of the young carpenter, he lent a manuscript copy of Professor Saunderson's discoveries. The blind professor had prepared several lectures on natural philosophy for the use of his students, but they were never intended for publication. Young Harrison now proceeded to copy them out, together with the diagrams. Sometimes, indeed, he spent the greater part of the night in writing or drawing.

As part of his business, he undertook to survey land, and to repair clocks and watches, besides carrying on his trade of a carpenter. He soon obtained a considerable knowledge of what had been done in clocks and watches, and was able to do not only what the best professional workers had done, but to strike out entirely new light in the clock and watch-making business. He found out a method of diminishing friction by adding a joint to the pallets of the pendulum, whereby they were made to work in the nature of rollers of a large radius, without any sliding, as usual, upon the

teeth of the wheel. He constructed a clock on the recoiling principle, which went perfectly and never lost a minute within fourteen years. Sir Edmund B. Denison says that he invented this method in order to save himself the trouble of going so frequently to oil the escapement of a turret clock, of which he had charge; though there were other influences at work beside this.

But his most important invention, at this early period of his life, was his compensation pendulum. Every one knows that metals expand with heat and contract by cold. The pendulum of the clock therefore expanded in summer and contracted in winter, thereby interfering with the regular going of the clock. Huyghens had by his cylindrical checks removed the great irregularity arising from the unequal lengths of the oscillations; but the pendulum was affected by the tossing of a ship at sea, and was also subject to a variation in weight, depending on the parallel of latitude. Graham, the well-known clockmaker, invented the mercurial compensation pendulum, consisting of a glass or iron jar filled with quicksilver and fixed to the end of the pendulum rod. When the rod was lengthened by heat, the quicksilver and the jar which contained it were simultaneously expanded and elevated, and the center of oscillation was thus continued at the same distance from the point of suspension.

But the difficulty, to a certain extent, remained unconquered until Harrison took the matter in hand. He observed that all rods of metal do not alter their lengths equally by heat, or, on the contrary, become shorter by cold, but some more sensibly than others. After innumerable experiments Harrison at length composed a frame somewhat resembling a gridiron, in which the alternate bars were of steel and of brass, and so arranged that those which expanded the most were counteracted by those which expanded the least. By this means the pendulum contained the power of equalizing its own action, and the center of oscillation continued at the same absolute distance from the point of suspension through all the variations of heat and cold during the year.

Thus, by the year 1726, when he was only twenty-three years old, Harrison had furnished himself with two compensation clocks, in which all the irregularities to which these machines were subject were either removed or so happily balanced, one metal against the other, that the two clocks kept time together in different parts of the house, without the variation of more than a single second in the month. One of them, indeed, which he kept by him for his own use, and constantly compared with a fixed star, did not vary so much as one minute during the ten years that he continued in the country after finishing the machine.

Living, as he did, not far from the sea, Harrison next endeavored to arrange his timekeeper for purposes of navigation. He tried his clock in a vessel belonging to Barton-on-Humber; but his compensating pendulum could there be of comparatively little use; for it was liable to be tossed hither or thither by the sudden motions of the ship. He found it necessary, therefore, to mount a chronometer, or portable timekeeper, which might be taken from place to place, and subjected to the violent and irregular motion of a ship at sea, without affecting its rate of going. It was evident to him that the first mover must be changed from a weight and pendulum to a spring wound up and a compensating balance.

He now applied his genius in this direction. After pondering over the subject in his mind, he proceeded to London in 1728, and exhibited his drawings to Dr. Halley, then Astronomer Royal. The Doctor referred him to Mr. George Graham, the distinguished horologer, inventor of the dead-beat escapement. After examining the drawings and holding some converse with Harrison, Graham perceived him to be a man of uncommon merit, and gave him every encouragement. He recommended him, however, to make his machine before again applying to the Board of Longitude. He accordingly returned home to Barrow to complete his task, and many years elapsed before he again appeared in London to present his chronometer.

The remarkable success which Harrison had achieved in his compensating pendulum could not but urge him on to further experiments. He was no doubt to a certain extent influenced by the reward of £20,000 which the English Government had offered many years before for an instrument that should enable the longitude to be more accurately determined by navigators at sea than was then possible; and it was with the object of obtaining pecuniary assistance to assist him in completing his chronometer that Harrison made his first visit to London to exhibit his drawings in 1728.

The Act of Parliament offering this superb reward was passed in 1714, in the twelfth year of the reign of Queen Anne. It was right that England, then rapidly advancing to the first position as a commercial nation, should make every effort to render navigation less hazardous. At that time the ship, when fairly at sea, out of sight of land, and battling with the winds and tides, was in a measure lost. No method existed for accurately ascertaining the longitude. The ship might be out of its course for one or two hundred miles, for anything that the navigator knew; and only the wreck of his ship on some unknown coast told of the mistake which he had made in his reckoning.

It may here be mentioned that it was comparatively easy to determine the latitude of a ship at sea every day when the sun was visible. The latitude—that is, the distance of any spot from the equator and the pole—might be found by a simple observation with the sextant. The altitude of the sun at noon is found, and by a short calculation the position of the ship may be ascertained.

The sextant, which is the instrument universally used at sea, was gradually evolved from similar instruments used from the earliest times. The object of these instruments has always been to find the angular distance between two bodies—that is to say, the angle of two straight lines which are drawn from those bodies to meet in the observer's eye. The simplest instrument of this kind may be well represented by a pair of compasses. If the hinge is held to the eye, one leg pointed to the distant horizon, and the other leg pointed to the sun, the two legs will be separated by a certain angle, which will be the angular distance of the sun from the horizon at the moment of observation.

Until the end of the seventeenth century the instrument used was of this simple kind. It was generally a large quadrant, with one or two bars moving on a hinge, to all intents and purposes a huge pair of compasses. The direction of the sight was fixed by the use of a slit and a pointer, much as in the ordinary rifle. This instrument was vastly improved by the use of a telescope, which not only allowed fainter objects to be seen, but especially enabled the sight to be accurately directed to the object observed.

The instruments of the pre-telescopic age reached their glory in the hands of Tycho Brahe. He used magnificent instruments of the simple "pair of compasses" kind—circles, quadrants, and sextants. These were for the most part ponderous fixed instruments, and of little or no use for the purposes of navigation. But Tycho Brahe's sextant proved the forerunner of the modern instrument. The general structure is the same; but the vast improvement of the modern sextant is due, first, to the use of the reflecting mirror, and, secondly, to the use of the telescope for accurate sighting. These improvements were due to many scientific men—to William Gascoigne, who first used the telescope, about 1640; to Robert Hooke, who, in 1660, proposed to apply it to the quadrant; to Sir Isaac Newton, who designed a reflecting quadrant;* and to John Hadley, who introduced it. The modern sextant is merely a modification of Newton's or Hadley's quadrant, and its present construction seems to be perfect.

It therefore became possible accurately to determine the position of a ship at sea as regarded its latitude. But it was quite different as regarded the longitude—that is, the distance of any place from a given meridian, eastward or westward. In the case of longitude there is no fixed spot to which reference can be made. The rotation of the earth makes the existence of such a spot impossible. The question of longitude is purely a question of TIME. The circuit of the globe, east and west, is simply represented by twenty-four hours. Each place has its own time. It is very easy to determine the local time at any spot by observations made at that spot. But, as time is always changing, the knowledge of the local time gives no idea of the position of a moving object—say, of a ship at sea. But if, in any locality, we know the local time, and also the local time of some other locality at that moment—say, of the Observatory at Greenwich—we can, by comparing the two local times, determine the difference of local times, or, what is the same thing, the difference of longitude between the two places. It was necessary therefore for the navigator to be in possession of a first-rate watch or chronometer, to enable him to determine accurately the position of his ship at sea, as respected the longitude.

Before the middle of the eighteenth century good watches were comparatively unknown. The navigator mainly relied upon his dead reckoning, without any observation of the heavenly bodies. He depended upon the accuracy of the course which he had steered by the compass, and the mensuration of the ship's velocity by an instrument called the log, as well as by combining and rectifying all the allowances for drift, lee-way, and so on, according to the trim of the ship; but all of these were liable to much uncertainty, especially when the sea was in a boisterous condition. There was another and independent course which might have been adopted—that is, by observation of the moon, which is constantly moving among the stars from west to east. But until the middle of the eighteenth century good lunar tables were as much unknown as good watches.

Hence a method of ascertaining the longitude, with the same degree of accuracy which is attainable in respect of latitude, had for ages been the grand desideratum for men "who go down to the sea in ships." Mr. Macpherson, in his important work entitled "The Annals of Commerce," observes: "Since the year 1714, when Parliament offered a reward of £20,000 for the best method of ascertaining the longitude at sea, many schemes have been devised, but all to little or no purpose, as going generally upon wrong principles, till that heaven-taught artist, Mr. John Harrison, arose;" and by him, as Mr. Macpherson goes on to say, the difficulty was conquered, having devoted to it "the assiduous studies of a long life."

The preamble of the act of Parliament in question runs as follows: "Whereas, it is well known by all that are acquainted with the art of navigation that nothing is so much wanted and desired at sea as the discovery of the longitude, for the safety and quickness of voyages, the preservation of ships and the lives of men," and so on. The act proceeds to constitute certain persons commissioners for the discovery of the longitude, with power to receive and experiment upon proposals for that purpose, and to grant sums of money not exceeding £2,000 to aid in such experiments. The clause of the act by which rewards are offered to such inventors or discovers as shall succeed in enabling the longitude to be ascertained within certain limits, is as follows:

"And for a due and sufficient encouragement to any such person or persons as shall discover a proper method for finding the said longitude, be it enacted by the authority aforesaid that the first author or authors, discoverer or discoverers, of any such method, his or their executors, administrators, or assigns, shall be entitled to, and shall have such reward as is hereinafter mentioned; that is to say, to a reward or sum of £10,000 if it determines the said longitude to one degree of a great circle, or sixty geographical miles; to £15,000 if it determines the same to two-thirds of that distance; and to £20,000 if it determines the same to one-half of the same distance; and that one moiety or half part of such reward or sum shall be due and paid when the said commissioners, or the major part of them, do agree that any such method extends to the security of ships within eighty geographical miles of the shores which are the places of the greatest danger, and the other moiety or half part when a ship, by the appointment of the said commissioners, or the major part of them, shall thereby actually sail over the ocean from Great Britain to any such port in the West Indies as these commissioners, or the major part of them, shall choose or nominate for the experiment, without losing their longitude beyond the limits before mentioned."

It will, in these days, be scarcely believed that little more than a hundred and fifty years ago a prize of not less than ten thousand pounds should have been offered for a method of determining the longitude within *sixty miles*, and that double the amount should have been offered for a method of determining it within *thirty miles!* The amount of these rewards is sufficient proof of the fearful necessity for improvement which then existed in the methods of navigation. And yet, from the date of the passing of the act in 1714 until the year 1736, when Harrison finished his first timepiece, nothing had been done toward ascertaining the longitude more accurately, even within the wide limits specified by the act of Parliament. Although several schemes had been projected, none of them had proved successful, and the offered rewards therefore still remained unclaimed.

To return to Harrison. After reaching his home at Barrow, after his visit to London in 1728, he began his experiments for the construction of a marine chronometer. The task was one of no small difficulty. It was necessary to provide against irregularities arising from the motion of a ship at sea, and to obviate the effect of alternations of temperature in the machine itself, as well as in the oil with which it was lubricated. A thousand obstacles presented themselves, but they were not enough to deter Harrison from grappling with the work he had set himself to perform.

Every one knows the beautiful machinery of a timepiece, and the perfect tools required to produce such a machine. Some of these Harrison procured in London, but the greater number he produced for himself. Many entirely new adaptations were required for his chronometer. Wood could no longer be employed, and he had therefore to teach himself to work accurately and minutely in brass and other metals. Having been unable to obtain any assistance from the Board of Longitude, he was under the necessity, while carrying forward his experiments, of maintaining himself by working at his trade of a carpenter and joiner. This will account for the very long period that elapsed before he could bring his chronometer to such a state that it might be tried with any approach to certainty in its operations.

Harrison, besides his intentness and earnestness in respect of the great work of his life, was a cheerful and hopeful man. He had a fine taste for music, and organized and led the choir of the village church, which attained a high degree of perfection. He invented a curious monochord, which was not less accurate than his clocks in the mensuration of time. His ear was distressed by the ringing of bells out of tune, and he set himself to remedy them; at the parish church of Hull, for instance, the bells were harsh and disagreeable, and by the authority of the vicar and church wardens he was allowed to put them into a state of exact tune, so that they proved entirely melodious.

But the great work of his life was his marine chronometer. He found it necessary, in the first place, to alter the first mover of his clock to a spring wound up, so that the regularity of the motion might be derived from the vibrations of balances, instead of those of a pendulum in a standing clock. Mr. Folkes, President of the Royal Society, when presenting the gold metal to Mr. Harrison in 1749, thus describes the arrangement of his new machine. The details were obtained from Harrison himself, who was present. He made use of two balances situated in the same plane, but vibrating in contrary directions, so that the one of these being either way assisted by the tossing of the ship, the other might constantly be just so much impeded by it at the same time. As the equality of the times of the vibrations of the balance of a pocket watch is in a great measure owing to the spiral spring that lies under it, so the same was here performed by the like elasticity of four cylindrical springs or worms, applied near the upper and lower extremities of the two balances above described.

Then came in the question of compensation. Harrison's experience with the compensation pendulum of his clock now proved of service to him. He proceeded to introduce a similar expedient into his proposed chronometer. As is well known to those who are acquainted with the nature of springs moved by balances, the stronger those springs are the quicker the vibrations of the balances are performed, and *vice versa;* so it follows that those springs, when braced by cold, or when relaxed by heat, must of necessity cause the time keeper to go either faster or slower, unless some method could be found to remedy the inconvenience.

The method adopted by Harrison was his compensation balance, doubtless the backbone of his invention. His "thermometer kirb," he himself says, "is composed of two thin plates of brass and steel, riveted together in several places, which, by the greater expansion of brass than steel by heat and contraction by cold, becomes convex on the brass side in hot weather and convex on the steel side in cold weather; whence, one end being fixed, the other end obtains a motion corresponding with the changes of heat and cold, and the two pins at the end, between which the balance spring passes, and which it alternately touches as the spring bends and unbends itself, will shorten or lengthen the spring, as the change of heat or cold would otherwise require to be done by hand in the manner used for regulating a common watch." Although the method has since been improved upon by Leroy, Arnold, and Earnshaw, it was the beginning of all that has since been done in the perfection of marine chronometers. Indeed, it is amazing to think of the number of clever, skillful, and industrious men who have been engaged for many hundred years in the production of that exquisite fabric—so useful to everybody, whether scientific or otherwise, on land or sea—the modern watch.

It is unnecessary here to mention in detail the particulars of Harrison's invention. These were published by himself in his "Principles of Mr. Harrison's Timekeeper." It may, however, be mentioned that he invented a method by which the chronometer might be kept going without losing a second of time. This was during the process of winding up, which was done once in a day. While the mainspring was being wound up, a secondary one preserved the motion of the wheels and kept the machine going.

After seven years' labor, during which Harrison encountered and overcame numerous difficulties, he at last completed his first marine chronometer. He placed it in a sort of movable frame, somewhat resembling what the sailors call a "compass gimbal," but much more artificially and curiously made and arranged. In this state the chronometer was tried from time to time in a large barge on the river Humber, in rough as well as in smooth weather, and it was found to go perfectly, without losing a moment of time.

Such was the condition of Harrison's chronometer when he arrived in London with it in 1735, in order to apply to the commissioners appointed for providing a public reward for the discovery of the longitude at sea. He first showed it to several members of the Royal Society, who cordially approved it. Five of the most prominent members—Dr. Halley, Dr. Smith, Dr. Bradley, Mr. John Machin, and Mr. George Graham—furnished Harrison with a certificate, stating that the principles of his machine for measuring time promised a very great and sufficient degree of exactness. In consequence of this certificate the machine, at the request of the inventor and at the recommendation of Sir Charles Wager, First Lord of the Admiralty, was placed on board a man-of-war, and carried, with Mr. Harrison, to Lisbon and back again. The chronometer was not affected by the roughest weather, or by the working of the ship through the vast rolling waves of the Bay of Biscay. By means of its exact measurement of time an error of almost a degree and a half (or ninety miles) in the computations of the reckoning of the ship was corrected at the mouth of the Channel.

Upon this first successful trial of his chronometer the Commissioners of Longitude gave Harrison the sum of £500, on condition that he should proceed to make further improvements in his machine. Mr. George Graham urged that the Commissioners should award him double the amount; but this was refused. At the recommendation of Lord Monson, however, Harrison accepted the sum as a help toward the heavy expenses and labor which he had incurred, and was

* Sir Isaac Newton gave his design to Edmund Halley, then Astronomer Royal. Halley laid it on one side, and it was found among his papers after his death in 1742, and twenty-five years after the death of Newton.

about to incur, in perfecting the machine. He was instructed to make his new chronometer of less dimensions than the first, which was thought too cumbersome and to occupy too much space on board.

He accordingly proceeded to make his second chronometer. It occupied a space of about only half the size of the first. He introduced several improvements. He lessened the number of the wheels, and thereby diminished friction. But the general arrangement remained the same. This second machine was finished in 1739. It was much more simple in its arrangement, and much less cumbrous in its dimensions. It answered even better than the first, and though it was not tried at sea its motions were sufficiently exact for finding the longitude within the nearest limits proposed by Parliament.

Not satisfied with his two machines, Harrison proceeded to make a third. This was of an improved construction, and occupied still less space, the whole of the machine and its apparatus standing upon an area of only four square feet. It was in such forwardness in January, 1741, that it was exhibited before the Royal Society, and twelve of the most prominent members signed a certificate of "its great and excellent use, as well for determining the longitude at sea as for correcting the charts of the coasts." The testimonial concluded: "We do recommend Mr. Harrison to the favor of the Commissioners appointed by Act of Parliament as a person highly deserving of such further encouragement and assistance as they shall judge proper and sufficient to finish his third machine." The Commissioners granted him a further sum of £500 accordingly. Harrison was now reduced to necessitous circumstances by his continuous application to the improvement of the timekeepers. He had also got into debt, and required further assistance to enable him to proceed with their construction.

Although Harrison had promised that the third machine would be ready for trial on August 1, 1743, it was not finished for some years after. In June, 1746, we find him again appearing before the Board, asking for further assistance. While proceeding with his work he found it necessary to add a new spring, "having spent much time and thought in tempering them." Another £500 was voted to enable him to pay his debts, to maintain himself and family, and to complete his machine.

Three years later he exhibited his third machine to the Royal Society, when he was awarded the gold medal for the year. In presenting it Mr. Folkes, the President, said to Mr. Harrison: "I do here, by the authority and in the name of the Royal Society of London, for the improving of natural knowledge, present you with this small but faithful token of their regard and esteem. I do, in their name, congratulate you upon the successes you have already had, and I most sincerely wish that all your future trials may in every way prove answerable to these beginnings, and that the full accomplishment of your great undertaking may at last be crowned with all the reputation and advantage to yourself that your warmest wishes may suggest, and to which so many years so laudably and so diligently spent in the improvement of those talents which God Almighty has bestowed upon you, will so justly entitle your constant and unwearied perseverance."

Mr. Folkes, in his speech, spoke of Mr. Harrison as "one of the most modest persons he had ever known." "In speaking of his own performances he has assured me that, from the immense number of diligent and accurate experiments he has made, and from the severe tests to which he has in many ways put his instruments, he expects he shall be able with sufficient certainty, through all the greatest variety of seasons and the most irregular motions of the sea, to keep time constantly, without the variation of so much as *three seconds in a week*, a degree of exactness that is astonishing and even stupendous, considering the immense number of difficulties, and those of very different sorts, which the author of these inventions must have had to encounter and struggle withal."

Although it is common enough now to make first rate chronometers—sufficient to determine the longitude with almost perfect accuracy in every clime of the world—it was very different then, at the time that Harrison was occupied with his laborious experiments. Although he considered this third machine to be the *ne plus ultra* of scientific mechanism, he nevertheless proceeded to construct a fourth timepiece, in the form of a pocket watch about five inches in diameter. He found the principles which he had adopted in his larger machines to apply equally well in the smaller; and the performances of the last surpassed his utmost expectations. But in the mean time, as his *third* timekeeper was, in his opinion, sufficient to supply the requirements of the Board of Longitude as respected the highest reward offered, he applied to the Commissioners for leave to try that instrument on board a royal ship to some port in the West Indies, as directed by the statute of Queen Anne.

It was not until March 12, 1761, that he received orders from his son William to proceed to Portsmouth, and go on board the Dorsetshire man-of-war, to proceed to Jamaica. But another tedious delay occured. The ship was ordered elsewhere, and William Harrison, after remaining five months at Portsmouth, returned to London. By this time John Harrison had finished his *fourth* timepiece—the small one—in the form of a watch. At length William Harrison set sail with this timekeeper from Portsmouth for Jamaica in the Deptford man-of-war, on November 18, 1761, and returned to England on March 26, 1762. On the arrival of the ship at Port Royal the timekeeper was found to be only five and one-tenth seconds in error, and during the voyage of over four months, on its return to Portsmouth in the Merlin, it had only erred one minute fifty-four and a half seconds. In the latitude of Portsmouth this only amounted to eighteen geographical miles, whereas the act required that it should only come within the distance of thirty miles or minutes of a great circle. One would have thought that Harrison was now clearly entitled to his reward of £20,000.

But the delays interposed by Government are long and tedious. Harrison had accomplished more than was requisite to obtain the highest reward. It was necessary for him to petition Parliament on the subject. Three reigns had passed; Anne had died; George I. and George II. had reigned and died; and now in the reign of George III. an act was passed enabling Harrison to obtain the sum of £5,000 immediately as part of the reward. But the Commissioners differed about the tempering of the springs. They required a second trial of the timekeeper. Two more years passed, and Harrison's son again departed with the instrument on board the Tartar for Barbados on March 28, 1764. He returned in about four months, during which time the instrument enabled the latitude to be ascertained within *ten* miles, or *one-third* the required geographical distance.

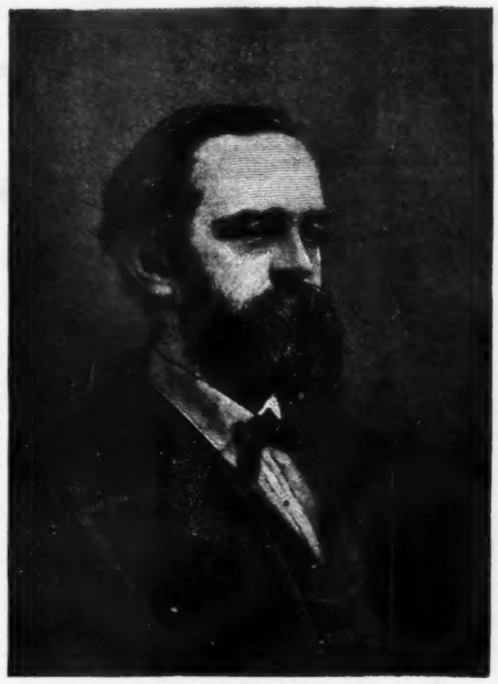
Harrison memorialized the Board again and again. In the following September they virtually recognized his claims by paying him on account £1,000. In February, 1765, the Board entered a minute on their proceedings that they were "unanimously of opinion that the said (Harrison's) timekeeper has kept its time with sufficient correctness, without losing its longitude in the voyage from Portsmouth to Barbados beyond the nearest limit required by the act of 12th of Queen Anne, but even considerably within the same." They would not give him the necessary certificate, though they were of opinion that he was entitled to be paid the full reward.

Harrison was now becoming old and feeble. He had attained the age of seventy-four. He had spent forty long years in working at the chronometers. He was losing his eyesight, and could not afford to wait much longer.

"Full little knowest thou, who hast not tried,
What hell it is in suing long to bide;
To lose good days, that might be better spent;
To waste long nights in pensive discontent;
To spend to-day to be put back to-morrow,
To feed on hope, to pine with fear and sorrow."

But Harrison had not lost his spirit. On May 30, 1765, he addressed another remonstrance to the Board, containing much stronger language than he had up to this time used. "I cannot help thinking," he said, "but I am extremely ill-used by gentlemen whom I might have expected a different treatment from; for if the act of the 12th of Queen Anne be deficient, why have I so long been encouraged under it, in order to bring my invention to perfection? And, after the completion, why was my son sent twice to the West Indies? Had it been said to my son, when he received the last instruction, 'There will, in case you succeed, be a new act on your return, in order to lay you under new restrictions, which were not thought of in the act of the 12th of Queen Anne'—I say, had this been the case, I might have some such treatment as I now meet with.

"It must be owned that my case is very hard; but I hope I am the first, and for my country's sake I hope I shall be the last, that suffers by pinning my faith upon an English act of Parliament. Had I received my just reward—for certainly it may be so called after forty years' close application of the talent which it has pleased God to give me—then my invention would have taken the course which all improvements in this world do; that is, I must have instructed



HENRY DRAPER.

workmen in its principles and execution, which I should have been glad of an opportunity of doing. But how widely this is different from what is now proposed, viz., for me to instruct people that I know nothing of, and such as may know nothing of mechanics; and, if I do not make them understand to their satisfaction, I may then have nothing!

"Hard fate indeed to me, but still harder to the world, which may be deprived of this my invention, which must be the case, except by my open and free manner in describing all the principles of it to gentlemen and noblemen who almost at all times have had free recourse to my instruments. And if any of these workmen have been so ingenious as to have got my invention, how far you may please to reward them for their piracy must be left for you to determine; and I must set myself down in old age, and thank God I can be more easy in that I have the conquest, and though I have no reward, than if I had come short of the matter and by some delusion had the reward!"

The Right Honorable the Earl of Egmont was in the chair of the Board of Longitude on the day when this letter was read—June 13, 1765. The Commissoners were somewhat startled by the tone which the inventor had taken. Indeed, they were rather angry. But Mr. Harrison, who was in waiting, was called in. After some rather hot speaking, and after a proposal was made to Harrison, which he said he would decline to accede to "so long as a drop of English blood remained in his body," he left the room. Matters were at length duly arranged. Another act of Parliament was passed, appointing the payment of the whole reward of £20,000 to the inventor; one moiety upon discovering the principles of the construction of his chronometers and assigning his four chronometers (one of which was styled a watch) to the use of the public, and the remaining moiety on sufficient proof of the correctness of the chronometers.

Mr. Harrison accordingly, made over to the Commissioners of Longitude his various timekeepers, and deposited in their hands correct drawings, so that other skillful makers might construct similar chronometers on the same principles. Harrison expressed the greatest readiness to explain his inventions, and to subject them to every required test. Indeed, there was no difficulty in making the chronometers, after the explanations and drawings which Harrison had published. An exact copy of his last watch was made by the ingenious Mr. Kendal, one of Harrison's apprentices. This chronometer was used by Captain Cook during his three years' circumnavigation of the globe, and was found to answer as well as the original. This, as well as Harrison's chronometer, is still to be seen at the Royal Observatory, and both are in a good going condition.

Although Harrison did not obtain the remaining moiety of his reward until 1767, two years after the above mentioned meeting of the Board, his labors were over, his victory was secured, his prize was won. Nowithstanding his delicacy of health he lived a few years longer. He died in 1776, at his house in Red Lion Square, in his eighty third year. It may be said of John Harrison that by the invention of his chronometer he conferred an incalculable benefit on science and navigation, and established his claim to be regarded as one of the greatest benefactors of mankind.—*Longman's Magazine.*

THE LATE DR. HENRY DRAPER.

DURING the past year, the National Academy of Sciences has lost by death seven out of its membership of less than one hundred—Professor John W. Draper (the father of the subject of this notice), Admiral John Rodgers, Professor William B. Rogers, Hon. George P. Marsh, Gen. J G. Barnard, Gen. G. K. Warren, and last, and saddest of all, Dr. Henry Draper.

The five first named were men advanced in years, whose work was substantially complete and finished, so that they had come to the natural end of honorable lives. Gen. Warren also had passed the age of fifty, and for some years had ceased to take any active part in scientific enterprise.

Dr. Henry Draper alone of all the seven was one from whom more even was to be expected in the future than the work he had already accomplished. He was cut off in the midst of his most successful achievements, at the very culmination of his course, just in the fullness of his strength. It is the simple truth—what another has said already—that "no greater calamity could have befallen American science than the recent and sudden death of Professor Henry Draper;" because he was now prepared by long experience, by the enthusiasm and confidence born of past success, by ripened judgment, and accumulated resources, for swifter advance than ever before in the important branch of research which he had made his own.

Only four days before he died, he entertained at his house a company of his scientific *confreres*, with a few other chosen friends. No one then present will ever forget the splendor and beauty of the scene, nor the genial hospitality of the host and his accomplished wife. Few of us ever heard his voice again. He was already suffering from a severe cold contracted by exposure in a storm during a hunting excursion among the Rocky Mountains (he had returned only a few days before), and the labor of preparing for this reception of his friends probably aggravated the trouble. That very night the hand of death was laid upon him, and after three days of suffering and struggle he was snatched away.

He was born in 1837, in Virginia; the second son of John William Draper, then at the beginning of his brilliant career. The father was at the time a young professor of chemistry in Hampden-Sydney College; he had come to this country from England a few years before, to take a professorship at Boydton, Va., having been induced to come to the United States, partly by the solicitations of his Virginian relatives, and partly by considerations connected with his romantic marriage to a young Portuguese lady of noble birth. In 1839 the elder Draper accepted the chair of chemistry in the New York University, and removed to the city with his family. Henry Draper, therefore, though by birth a Virginian, and mingling in his veins the blood of both the Anglo Saxon and the Latin races, was yet entirely a New Yorker in all his early associations and education, as well as in his later life.

He was educated in the schools of the city, and in the university with which his father was connected. He entered the freshman class at the age of fifteen, and went through the first two years of the college course. His instructors remember him as a bright, active youth, full of spirits, but with a strong taste and bent for scientific pursuits. At the beginning of his junior year he left the college for the medical school, and in 1858 he took his degree of M D. with distinguished honor.

His education was conducted throughout under the immediate and loving supervision of his father, from whom he inherited such qualities of mind and temperament as qualified him pre-eminently for the work he was to do. A writer in *Harper's Weekly*, speaking of this, says:

"He had for a companion, friend, and teacher from childhood one of the most thoroughly cultivated and original scientific men of the present age, who attended carefully to his instruction, and impressed upon him deeply the bent of his own mind in the direction of science. The boy was, in fact, immersed in science from his youngest years; and not merely crammed with its results, but saturated with its true spirit at its most impressible period; he was taught to love science for the interest of its inquiries, and was early put upon the line of investigation in which he has won his celebrity. He inherited not only his father's genius, but his problems of research.

"Dr. John W. Draper was an experimental investigator of such fertility of resource, and such consummate skill, that the European *savants* always deplored his proclivity to literary labors as a great loss to the scientific world. Henry Draper inherited from his father in an eminent degree the aptitude for delicate experimenting, and a fine capacity of manipulatory tact."

Nothing could be more beautiful than the relation and intercourse between this father and son in later years: on one side was the sincerest filial devotion, respect and admiration; on the other, paternal pride and confidence; on both sides, the warmest affection and perfect sympathy of purpose and idea.

Dr. Henry Draper began his researches before he left the college walls. His graduating thesis was a really valuable investigation of the functions of the spleen, and was conducted by means of microphotography, an art then only newly born. In the course of this work he discovered the great value of palladium protochloride in the darkening of collodion negatives. The year after his graduation was spent in Europe; and there, while he did not fail to appreciate and enjoy all that is interesting to every man of culture, still he was most interested in the places, methods, and instruments of scientific research. His visit to the great six-foot reflecting telescope of Lord Rosse, by far the largest ever constructed, gave to his ambition a stimulus and direction which influenced his whole life and largely determined his career.

On his return he received an appointment in Bellevue Hospital, which he retained for sixteen months, with the intention of practicing medicine. In 1860, however, he abandoned this purpose; and by accepting the chair of physiology in the academic department of the university, he definitely adopted the profession of an instructor. During the civil war his work was for a time interrupted by a short term of service in 1862 as surgeon of the twelfth regiment of New York volunteers; but a military career had few attractions for him, and as soon as he was no longer needed he returned to the duties of his chair. In 1866 he was appointed to the professorship of physiology in the medical school. He retained this post until 1873, when he resigned it, but continued to give the instruction in analytical chemistry in the academic department. At his father's death he was appointed to fill the vacant chair, and accepted the position; but only a few months before his death he resigned, and finally severed his connection with the university in order to give himself more entirely to research. At the time when he accepted the chair of physiology in the medical school, and became its manager, the institution had just lost its building by fire, with all its valuable collections. The young director immediately replaced them, largely by funds furnished by himself, and partly by assistance secured from others through his indomitable energy and skillful tact. The school, which seemed to be destroyed, was rehabilitated, and brought to its present state of flourishing prosperity.

His resignation in 1873 was necessitated by the heavy labor and responsibility imposed upon him as managing trustee of the immense estate of his father-in-law, the late Courtlandt Palmer, whose daughter he had married in 1867.

As a lecturer and instructor he was eminently successful. Says a writer in the *University Quarterly* (the college magazine of the New York University):

"His lectures are so interesting and absorbing to his hearers that the question of order, which in some recitation rooms assumes large proportions, is hardly even thought of with him. After class, an eager group surrounds him; and every tap by inquiring students is followed by a rich stream of information from a mind whose varied treasures always lie at instant command."

But he was still more eminent and successful as an investigator. We have already mentioned his first essay of the sort, and it was soon followed by others more extensive. Immediately upon his return from Europe he began the construction of a fifteen and a half inch reflecting telescope, and carried the work to a satisfactory conclusion. With it he took a photograph of the moon, fifty inches in diameter, the largest ever made, and one of the finest.

Encouraged by this success he aimed still higher, and built another reflector of twenty-eight inches aperture, which was completed in 1872. This, with its equatorial mounting and perfect driving clock, was wholly the work of his own hands. It was intended and used successfully for the purpose of photographing the spectra of stars. As President Barnard has said, "It was probably the most difficult and costly experiment in celestial chemistry ever made." It was with this instrument that in August, 1872, he first succeeded in obtaining a photograph of a star-spectrum, showing its characteristic lines: the star was Vega, and the lines were those of hydrogen. Since then he has taken the spectra of more than a hundred stars, and at the time of his death was preparing to push the work much farther. Most of the later photographs were made with an exquisite refractor of eleven and a half inches aperture, by Clark & Sons. This telescope, which he has found much more convenient than the reflectors, is provided with a special correcting lens for photographic work; and it was with this that he made those wonderful photographs of the nebula of Orion which were the fruit of his long and weary labors during the last two winters. For the most part he was accustomed to carry on his astronomical work in the summer, while residing at his country seat on the Hudson; in the winter he generally spent most of the time in the city, and gave himself mainly to laboratory research. In 1872, as a first step toward the interpretation of stellar spectra, he made a photograph of the diffraction spectrum of the sun, extending from below G to O. Others have since then taken pictures of small portions of the spectrum on a larger scale; but his photograph still remains classical and standard, and is recognized as such abroad as well as here.

In 1874 he was invited by the Transit of Venus Commission to superintend its photographic department; and he did so with such success, that on the completion of his labors the United States Government caused a special gold medal to be struck in his honor at the Philadelphia mint. Upon the face it bears the inscription, "*Decori decus addit avito;*" on the reverse, "*Famam extendere factis, hoc virtutis opus.*"

Next he took up his famous research as to the presence of the non-metals in the solar atmosphere, and in 1877 published his paper announcing the discovery of oxygen in the sun. The investigation was exceedingly protracted and laborious, and involved an expense of several thousand dollars; it was carried out by means of photography, several hundred plates having been made which show the solar spectrum confronted with that of the gas. In these plates we find the diffuse, hazy, bright lines of the oxygen spectrum coinciding, not with *dark* lines of the solar spectrum, but with certain brighter bands or interspaces. How this can be, it is far from easy to explain—why oxygen alone should act in this unprecedented way. Naturally there has been some skepticism and discussion as to the correctness and soundness of his conclusion; but no one with an unprejudiced mind can, we think, resist the evidence after careful examination of the plates, especially those obtained during his second and still more elaborate investigation of the subject in 1878–79.

In the summer of 1878, Dr. Draper organized a party for the observation of the solar eclipse of July 29. His station was at Rawlins, Wyoming Territory; and he succeeded, as did many others, in getting a fine photograph of the corona; he also succeeded, as no one else did, in getting a photograph of its spectrum, which, however, at that time was almost simply continuous.

In 1881 he obtained photographs of the spectrum of the great comet of that year, and also of the nebula of Orion and its spectrum. These pictures of the nebula are among the most remarkable and interesting specimens of celestial photography in existence.

Dr. Draper was not a prolific writer; but everything he wrote was valuable—clear, logical, and effective. Early in his career he published an excellent text book of chemistry; and his paper upon the construction of silvered-glass telescopes, published by the Smithsonian Institution, is a work of great importance. In the different scientific journals of England and the United States, he has from time to time published numerous papers giving accounts of the different researches. Our space forbids a catalogue, but they are mostly enumerated in the obituary notice published in the January number of the *Popular Science Monthly*.

Considerable unpublished work remains behind. Among other things should specially be noted the ingenious contrivance by which he succeeded in compelling a prism of bisulphide of carbon to perform satisfactorily in spite of changing temperature; and the equally interesting invention for working the Edison incandescent lamp by means of a gas engine, without the disagreeable fluctuation of light which usually accompanies the use of such an engine.

Dr. Draper was a member of the Century and Union League clubs, and occupied a high social position. With politics he did not meddle to any extent, though he was always patriotic and interested in the public welfare. He was connected with numerous scientific bodies in the city and country, and with many abroad. Though one of the youngest members of the National Academy of Sciences, he was one of the most effective and influential. Last summer his *alma mater* and the University of Wisconsin honored themselves and him by conferring upon him simultaneously, but independently, the degree of LL.D.

Excepting his early death, Dr. Draper was a man fortunate in all things: in his vigorous physique, his delicate senses, and skillful hand; in his birth and education; in his friendships; and especially in his marriage, which brought him not only wealth and all the happiness which naturally comes with a lovely, true-hearted, and faithful wife, but also a most unusual companionship and intellectual sympathy in all his favorite pursuits. He was fortunate in the great resources which lay at his disposal, and the wisdom to manage and use them well; in the subjects he chose for his researches, and the complete success he invariably attained.

In person he was of medium height, compactly built, with a pleasing address, and keen black eye, which missed nothing within its range. He was affectionate, noble, just, and generous; a thorough gentleman with a quick and burning contempt for all shams and meanness; a friend most kind, sympathetic, helpful, and brotherly; genial, wise, and witty in conversation; clear-headed, prudent, and active in business; a man of the highest and most refined intellectual tastes and qualities; a lover of art and music, and also of manly sports, especially the hunt; of such manual skill that no mechanic in the city could do finer work than he; in the pursuit of science, able, indefatigable, indomitable, sparing neither time, labor, nor expense.

His loss is lamented keenly, not only by those to whom it is a personal bereavement, but by every sincere lover of truth and science. It must be long before another can be found of such abilities, means, and versatility, to carry on his unfinished work.

But it is violating no confidence to add that his wife, who for fifteen years was his untiring assistant in all his labors, who knew all his plans, and thoroughly understood them too, now hopes and intends to find some way to have his work continued, to utilize the magnificent apparatus he had collected, and so to perpetuate his memory, and keep it forever green by providing for the accomplishment of his most cherished purposes: *Monumentum aere perennius.—Charles A. Young, in Science.*

THE Quincy Market Cold Storage Company, of Boston, are said to have the largest refrigerating building in the world. It is of stone and brick, 160 by 80 feet in size, and 70 feet in height. The capacity is 800,000 cubic feet, the cost $200,000, and the ice chamber holds 600,000 tons of ice. It will be used for storing dressed beef and mutton. The Chicago refrigerating cars unload at the door.

RICHARD'S REGISTERING APPARATUS.

MESSRS. RICHARD BROS., manufacturers of instruments of precision at Paris-Belleville, have devised a series of apparatus comprising thermometers, barometers, and hygrometers, which present the one character in common of inscribing their indications in ink, in a continuous manner, upon a sheet of paper ruled in squares and carried along by a clockwork movement. These instruments are arranged so that they can be easily moved about from place to place, their mechanical arrangements are so simple that any inexperienced person can use them, and their price is so low as to bring them within the reach of all.

Arrangement of the Registering Mechanism.—All the apparatus under consideration are arranged according to one type. All their parts are supported on a base surmounted by a glass case which allows the tracing pen and the paper to be seen. In the apparatus for use in apartments, the mounting of the cases is of wood, but in those designed to be placed in the open air it is of metal, as is also the base that supports the whole. The part designed to receive the registerings, including the clockwork movement, is identical in all the instruments, and this explains the moderate price at which they can be manufactured.

The registering device consists of a vertical drum, movable around an axis, and in the interior of which is placed a clockwork movement. The upper end of this drum is provided with two apertures (closed by disks pivoted at one side) for the passage of the winding and regulating keys. The lower end is traversed by one of the axes of the wheelwork, upon which is mounted externally a pinion. This latter gears with a fixed wheel keyed upon a rod which is mounted on the base of the apparatus, and which serves as the axis upon which the drum revolves. It results from this arrangement that the movement of the wheelwork revolves the toothed pinion which performs the role of a planet wheel, and brings about a general rotary motion of the drum containing the motor. It results also that the drum and its clockwork movement may be easily separated from the rest of the system, it being only necessary for this purpose to unscrew a nut so as to disengage the drum.

The spacing of the vertical lines on the paper carried by the drum is regulated according to the nature of the instruments. If these lines were strictly rectilinear, and applied exactly in the generatrices, it would be necessary to give the pen a strictly vertical motion, and this would involve a complication in the parts, which, by creating passive resistances, would detract from the sensitiveness of the apparatus. Messrs. Richard have got over this difficulty (which has been met by all who have hitherto constructed apparatus of this kind) by contenting themselves with a solution which, although only approximate, gives sufficient accuracy in practice. The apparatus are all provided with a long style, movable in a vertical plane, and having a rotary motion, and are so arranged that the plane described by the said style is disposed tangentially to the cylinder. The pen carried by the extremity of the style is so mounted that it shall be exactly applied against the contact generatrix of the cylinder and plane, when the style is in its mean position of oscillation. As a consequence of this arrangement, and of the flexibility of the style, the pen, in the vertical rotary motion of the style, does not leave the surface of the paper, but traces thereon a slightly inflexed line. The error that might result from such inflection is corrected by arranging the lines according to the curve thus described on the surface of the cylinder. In practice these lines are confounded on the paper with the successive portions of circumferences traced with a constant radius equal to the length of the style.

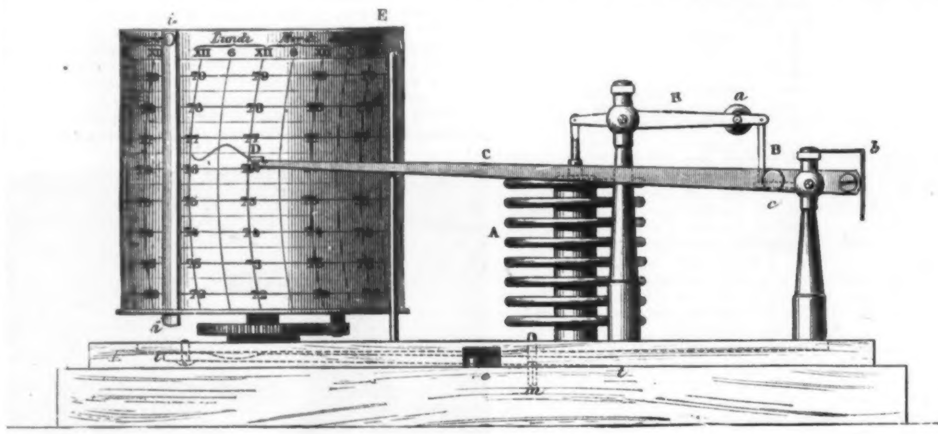


FIG. 1.—ELEVATION.

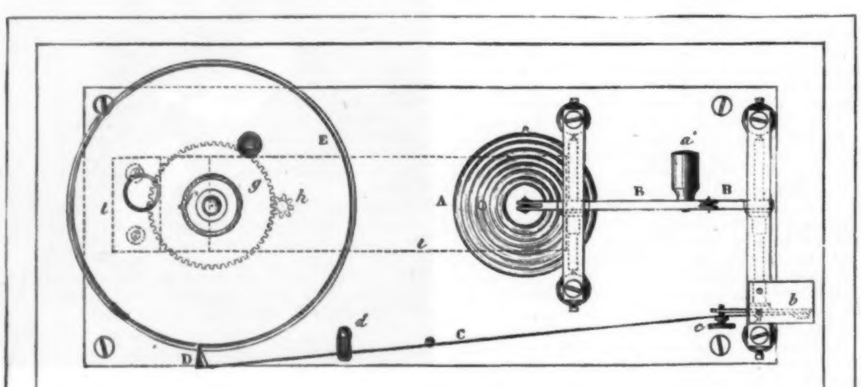


FIG. 2.—PLAN.

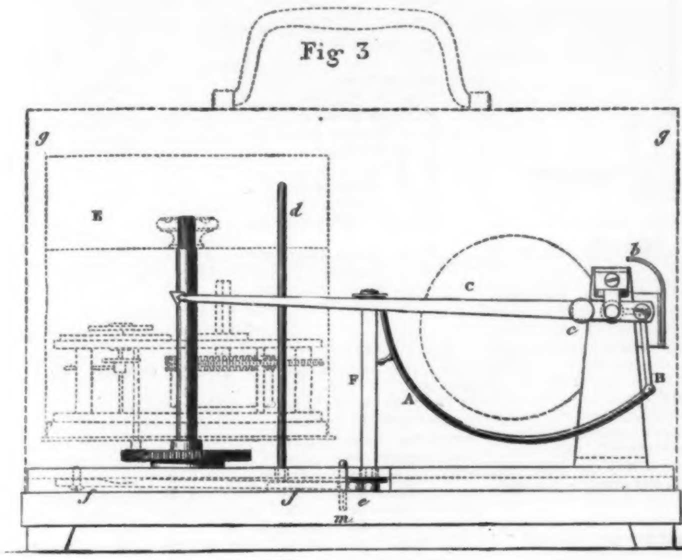
REGISTERING BAROMETER.

As may be seen, this simple arrangement, that the transverse flexibility of the style renders possible, permits of receiving directly upon a rectangular sheet the numerous tracings of the registering apparatus. Each sheet of ruled paper is fixed very simply on the cylinder by means of a flat spring which presses against the overlapping edges.

One of the most striking peculiarities of these instruments lies in the construction of the tracing pen. This consists simply of a small reservoir of thin metal in the form of a reversed triangular pyramid. One of the surfaces of the latter is affixed to the style, and its apex, which grazes the surface of the paper, is slit on one side, like the point of a pen, in order to cause a flow of the ink with which the reservoir is filled. The ink used is a mixture of aniline black and glycerine.

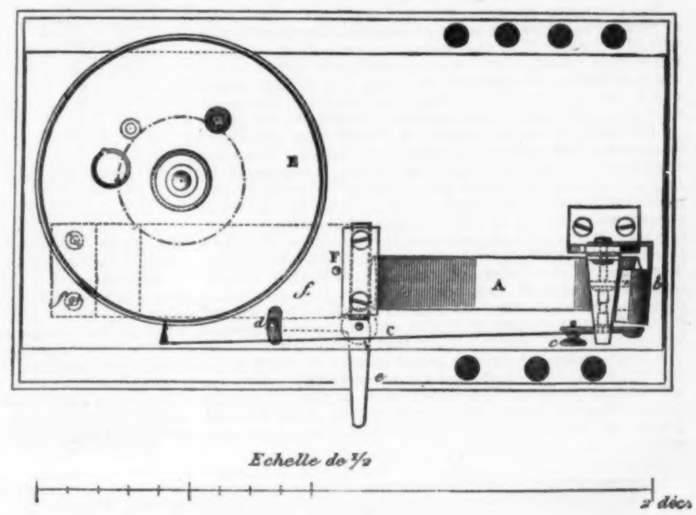
Registering Barometers (Figs. 1 and 2).—The barometers to which the Messrs. Richard apply the registering device just mentioned, are aneroid instruments of special construction.

Fig. 3



ELEVATION.

Fig. 4

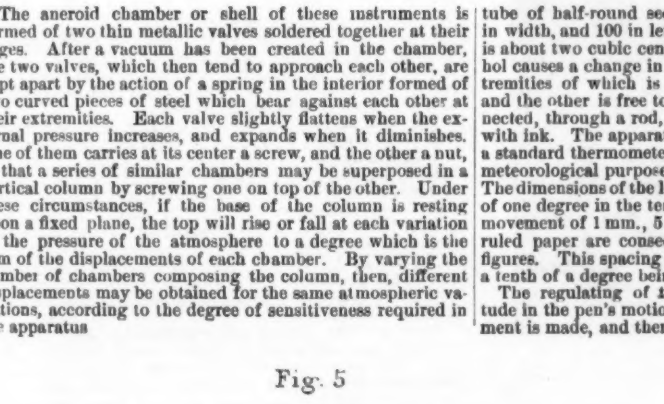


PLAN.

REGISTERING THERMOMETER.

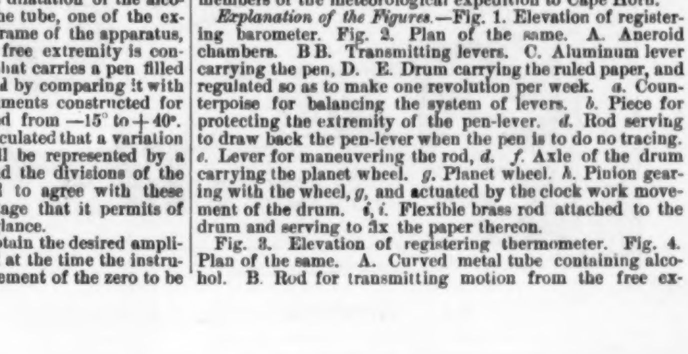
The aneroid chamber or shell of these instruments is formed of two thin metallic valves soldered together at their edges. After a vacuum has been created in the chamber, the two valves, which then tend to approach each other, are kept apart by the action of a spring in the interior formed of two curved pieces of steel which bear against each other at their extremities. Each valve slightly flattens when the external pressure increases, and expands when it diminishes. One of them carries at its center a screw, and the other a nut, so that a series of similar chambers may be superposed in a vertical column by screwing one on top of the other. Under these circumstances, if the base of the column is resting upon a fixed plane, the top will rise or fall at each variation in the pressure of the atmosphere to a degree which is the sum of the displacements of each chamber. By varying the number of chambers composing the column, then, different displacements may be obtained for the same atmospheric variations, according to the degree of sensitiveness required in the apparatus

Fig. 5



ELEVATION.

Fig. 6



PLAN.

REGISTERING HYGROMETER.

In barometers designed for meteorological observations the Messrs. Richard employ eight chambers for each column. Under such circumstances, and with the amplification given by the style, the pen traverses the total height of the registering drum for a variation in atmospheric pressure equivalent to a height of eight centimeters of mercury.

The movements of the top of the column of chambers are made to move the extremity of the short arm of a lever, whose longer arm forms the registering style. In order to avoid all resistance, which might falsify the indications of the apparatus, the lever is balanced by a counterpoise whose position may be regulated by a set-screw. This lever amplifies the movements of the top of the column about forty times. Moreover, by displacing the axis of rotation, the ratio of such amplification may be slightly varied. The barometer, when once regulated, undergoes no apparent variations as regards the amplitude of its oscillations; and the only change that can be observed with time is a general movement due to a slow variation in the state of equilibrium of the metal composing the chambers, and which is equivalent to a displacement of the zero of the scale. To correct this effect, the entire column is mounted upon a solid base that may be raised or lowered by a regulating device actuated by a screw that is maneuvered by a special key. A concordance may thus be established at any moment between the indications of the instrument and those of a mercurial barometer. To prevent the temperature from exerting a disturbing influence on the indications of the barometer, a small quantity of air is left in one of the chambers.

Registering Thermometers (Figs. 3 and 4).—The thermometer employed by the Messrs. Richard is a curved copper tube of half-round section, measuring about 18 millimeters in width, and 100 in length, filled with alcohol. Its capacity is about two cubic centimeters. The dilatation of the alcohol causes a change in the curve of the tube, one of the extremities of which is fixed to the frame of the apparatus, and the other is free to move. This free extremity is connected, through a rod, with a lever that carries a pen filled with ink. The apparatus is graduated by comparing it with a standard thermometer. The instruments constructed for meteorological purposes are graduated from —15° to +40°. The dimensions of the levers are so calculated that a variation of one degree in the temperature shall be represented by a movement of 1 mm., 5 in the pen, and the divisions of the ruled paper are consequently spaced to agree with these figures. This spacing has the advantage that it permits of a tenth of a degree being noted at a glance.

The regulating of the levers to obtain the desired amplitude in the pen's motion is performed at the time the instrument is made, and there is no displacement of the zero to be feared as a consequence of molecular changes in the metal with time. The error resulting from such displacement, however, may be easily corrected by raising the fixed part of the tube more or less, this being for that purpose mounted on a cylinder whose height may be regulated by means of a set-screw and key.

The arrangements adopted in the construction of these thermometers secures great sensitiveness; since, by reason of the material of which it is composed, the tube is pre-eminently a conductor of heat, presents a wide surface in contact with the air, and has so small a capacity that the alcohol that it contains very quickly puts itself in equilibrium with the surrounding temperature.

Registering Hygrometers (Figs. 5 and 6).—Messrs. Richard have recently succeeded in constructing hygrometers whose indications may be inscribed upon a registering drum, as in the preceding apparatus.

The difficulties to be overcome in constructing a really practical hygrometer are well known. Those made of hair are very sensitive, but do not preserve their qualities for any length of time, and it is rare that one can be found in a condition to work. By the use of gold beater's skin, which has the same properties as hair, but possesses the further advantage of stability, Messrs. Richard appear to have made a long stride toward a solution of the problem.

They employ a sheet of this substance stretched over a metallic drum, and arrange a small lever, so that it shall bear against the center of the membrane by means of a small spring and intervening rod. According to the state of dryness of the air, the gold-beater's skin stretches more or less, and this motion is amplified by the style that carries the pen.

The results obtained with this instrument have been so satisfactory that one of them was selected for use by the members of the meteorological expedition to Cape Horn.

Explanation of the Figures.—Fig. 1. Elevation of registering barometer. Fig. 2. Plan of the same. A. Aneroid chambers. B B. Transmitting levers. C. Aluminum lever carrying the pen, D. E. Drum carrying the ruled paper, and regulated so as to make one revolution per week. *a.* Counterpoise for balancing the system of levers. *b.* Piece for protecting the extremity of the pen-lever. *d.* Rod serving to draw back the pen-lever when the pen is to do no tracing. *e.* Lever for maneuvering the rod, *d.* *f.* Axle of the drum carrying the planet wheel. *g.* Planet wheel. *h.* Pinion gearing with the wheel, *g*, and actuated by the clock work movement of the drum. *i, i.* Flexible brass rod attached to the drum and serving to fix the paper thereon.

Fig. 3. Elevation of registering thermometer. Fig. 4. Plan of the same. A. Curved metal tube containing alcohol. B. Rod for transmitting motion from the free extremity of the tube A to the pen-lever. C. Brass pen-lever. E. Drum carrying the ruled paper. F. Cylinder carrying the fixed extremity of the thermometer tube, and resting on a plate *ff*, whose position is regulated by a screw, *m.* *b.* Piece for protecting the extremity of the lever, C. *c.* Screw for regulating the pressure of the pen on the drum. *d.* Rod for drawing back the lever, C. *e.* Lever for maneuvering the rod, *e.* *g.* Sheet iron case for protecting the instrument.

Fig. 5. Elevation of registering hygrometer. Fig. 6. Plan of the same. A. Gold-beater's skin stretched over a drum. B. Rod for transmitting motion from the membrane to the pen-lever, through the intermedium of a small lever. C. Brass lever carrying the pen, D. E. Drum carrying the

ruled paper. F. Column carrying the drum and resting upon a plate, *f*, that may be regulated by a screw. *a*. Counterpoise for balancing the system of levers. *b*. Piece for protecting the end of the lever, C. *c*. Screw for regulating the pressure of the pen upon the drum. *d*. Rod for drawing back the lever, C. *e*. Lever for maneuvering the rod, *c*. *g*. Protecting case of sheet iron.—*Bulletin de la Société d'Encouragement.*

CRAMPTON'S HYDRAULIC TUNNELING MACHINE.

WE have already given some details in regard to the progress being made in boring the Channel tunnel, and in the SCIENTIFIC AMERICAN of April 22, 1882, we have described the Beaumont compressed-air machine employed in the work of excavation. In Fig. 1, borrowed from *La Nature*, we present a view of another machine which is being used in the same undertaking, and which differs from Beaumont's in the fact that the power is furnished by water under pressure, thus allowing of greater rapidity being attained in the work. This same water, on leaving the machine, is further utilized for carrying the excavated chalk through a conduit to the bottom of the working shaft, thus doing away with the necessity for cars.

The Crampton machine, which, from a mechanical point of view, is based on the same principle as Beaumont's, consists of a circular disk, two meters in diameter, mounted on a horizontal shaft, which is actuated by the piston of the water cylinder. In front of this disk are seventy knives which cut out the chalk in rings 7 centimeters wide by 2 in thickness, and behind it are arranged buckets which gather up the debris from the bottom of the heading and empty them into a chute that carries them to the mixer. The whole apparatus forms a movable frame which is supported by fourteen wheels, and which may be moved forward in proportion as the work advances, so as to keep the knives in contact with the face of the cutting. The water, on making its exit from the cylinder, is directed into the chute in order to aid the descent of the debris into the mixer. The object of this latter apparatus is to intimately mix the chalk with water to a consistence such that it may be led by pipes to the base of the shaft and be pumped up to the surface. The proper consistence for such purpose is obtained by using a weight of water triple that of the chalky debris. The very arrangement of the tunnel permits of securing this removal of the excavated material automatically. The tunnel presents the form of an elongated W, and the excavation reaches, then, its highest point in the middle of the Channel, whence the two sides shelve. This middle point will be at a depth of about 100 meters beneath the bottom of the sea, and the diverging galleries will extend on each side with a slope $\frac{1}{1000}$, sufficient to secure a flow of the muddy current, under the influence of gravity alone, to a distance of 16 kilometers from the center, so as to reach the point, C, at a depth of 137 meters, at the bottom of the working shaft at each end.

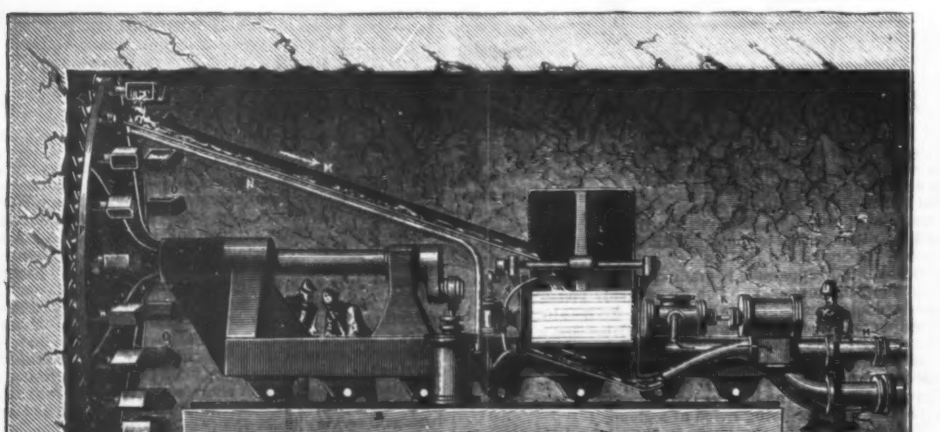


FIG. 1.—CRAMPTON'S HYDRAULIC TUNNELING MACHINE.

The gallery of wide section, which is to serve for passage of trains, stops at the point D, at a depth of 129 meters, and at a distance of only 12 kilometers from the center. Beyond from D to C, the gallery is prolonged by another one of small section, serving only for the removal of the water. Starting from D, the main tunnel rises with a steeper grade, and ends outside at Dover. The arrangement of the tunnel is the same at Calais. The distance thus traversed is about 12 kilometers, which, as may be seen, carries the total length to be pierced up to 48 kilometers. In the work on the English side, the first well is to be sunk at Fanhole, to join the main tunnel at a depth of 36 meters, and another at Saint Margaret, at a depth of 137 meters, to serve as a working shaft.

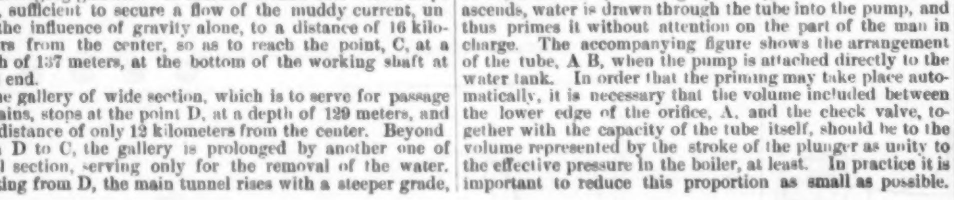
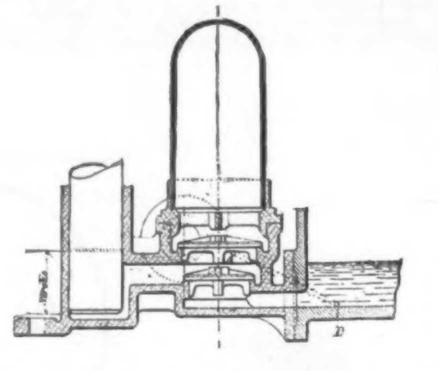


FIG. 2.—LONGITUDINAL SECTION OF HALF THE CHANNEL TUNNEL.

The motive power is furnished by a head of sea water. The tunneling machine requires a power of about 425 horses to cut the chalk and crush the debris, and the lifting pumps absorb on their side a power of about 500 horses. The velocity at which the disk of the perforator runs is ten revolutions per minute, which gives the extreme knives a velocity of 350 meters. The crusher is a cylinder 1·2 m. in diameter, and 0·6 m. long, making 33 revolutions per minute. It is capable of crushing about 10 tons per hour, with a power of one-half horse.

PRIMER FOR PUMPS.

M. AUGUSTIN NORMAND has recently communicated to the *Société des Ingénieurs Civils* an account of an exceedingly simple and ingenious method which he has devised for expelling the air which accumulates in the clearance space of a pump barrel and in the valve chambers. Ordinarily this is effected by means of a pet cock placed at the highest point to which the air has access. When it is desired to start the pump the cock is opened, and the finger of the attendant placed over the orifice to act as a valve, allowing air to escape when the internal pressure is greater than that of the atmosphere, and preventing its return during the upstroke of the plunger. In a few strokes the ejection of water shows



that the air is expelled and the pump is working. But when, as in surface condensing engines, the capacity of the pumps is much larger than the average volume passed through them, and also when the boiler pressure is high and the speed great, conditions which necessitate the use of large valves, it often happens that pumps lose their water when in action.

To obviate the necessity of pet cocks and to prevent the cessation of pumping, M. Normand introduces into the pump, at the highest point at which the air can accumulate, a small pipe, from one eighth inch to three-sixteenth inch in internal diameter, whose other end opens into the tank from which the water is to be drawn. When the plunger descends, the air which may be in the barrel is compressed and escapes through this tube, bubbling up through the water. When it ascends, water is drawn through the tube into the pump, and thus primes it without attention on the part of the man in charge. The accompanying figure shows the arrangement of the tube, A B, when the pump is attached directly to the water tank. In order that the priming may take place automatically, it is necessary that the volume included between the lower edge of the orifice, A, and the check valve, together with the capacity of the tube itself, should be to the volume represented by the stroke of the plunger as unity to the effective pressure in the boiler, at least. In practice it is important to reduce this proportion as small as possible. The volume of water that escapes through the tube, A B, during the working of the pump should be a small fraction of the amount received, or else the performance of the pump will be seriously impaired. When the pump is fixed at a distance from the tank, the suction pipe should be inclined in such a way that the expelled air can return to the tank.

LOCOMOTIVES FOR VICTORIA.—The question of obtaining a supply of locomotives out of the colony for the Railway Department of Victoria has engaged the attention of the Minister of Railways and his officers. Orders have been sent to the Baldwin Locomotive Works, Philadelphia, for the delivery of ten locomotives of the same pattern as some supplied by the same firm, and now in use on the Victorian railways. These will be placed on board a special steamer, and will be delivered in Melbourne within six months.

PAINTING THE NEW YORK AND BROOKLYN SUSPENSION BRIDGE.

IN June last the trustees of the New York and Brooklyn bridge advertised for proposals for furnishing about 10,000 gallons of paint, to be made according to the following formula: 70 pounds first quality white oxide of zinc; 30 pounds of best white lead; 6 gallons raw Calcutta linseed oil, with such staining material as may be necessary to give the desired color. The paint to be ground and to weigh not less than 18 pounds per standard gallon. In order to see that these conditions would be complied with, the trustees stipulated that they be allowed to place an inspector in the manufactory of the contractor, and to whom should be afforded every facility for examining the material, process, packing, etc. Should any of the paint be found to contain other materials than those specified, the trustees had the right to annul the contract and to obtain any balance that might be from such sources as would be for the best interests of the work; but if the cost be more than that of the contract, then the contractor will be held for the difference in price.

On July 5, the following bids were opened:	Per gal.
Ed. Smith & Co.	$1.52
" " second bid	1.26
Seeley Bros.	1.20
Chas. E. McBride	.90
Harrison Bros. & Co.	1.40
N. J. Enamel Paint Co.	1.35
C. A. Woolsey	1.16½
E. Blunt	1.20
F. W. Devoe & Co.	1.28
C. T. Raynolds & Co.	1.25
John W. Masury & Son	1.15
" " linseed oil	1.05
H. W. Johns Mfg. Co.	1.47
W. P. Husband	1.65
Union White Lead Mfg. Co. Paint 6 3-10c. per lb. Raw Am. linseed oil, 63c. per gal.	

The bid of Chas. E. McBride at 90 cents per gallon was withdrawn, and the contract awarded to Messrs. Masury & Son at $1.15.

The position of the bridge subjects its iron and steel work to atmospheric influences which are extremely corroding. Under these circumstances the formula above given for mixing the paint was believed to be the most advantageous that could be obtained. It was also believed that not only would the surfaces be perfectly protected, but that the paint itself would have such durable qualities that its renewal would be unnecessary for some time.

In speaking of the condition that the paint must weigh 18 lb. to the gallon, one of our esteemed contemporaries states that, "Made up with all honest intention, so as to give as good a paint as the formula is capable of making, the weight will be but 17¼ lb. per gallon. Sealed up in tin cans this paint will weigh just 18 lb. per standard gallon." We were informed by Mr. C. C. Martin, First Assistant Engineer of the bridge, that one U. S. sealed gallon, on Fairbanks' standard scales, weighed over 18 lb.

In order that there may be no deception, small quantities of paint from the same package will be analyzed by the contractors and by the bridge authorities, and the results compared. This will be repeated as often as may be deemed essential to the best interests of the work.

The task of painting the bridge is progressing rapidly. The paint is mixed with oil by the company in such proportion as will render it of the desired consistency. No drier is used, as, when ten or twelve hours of dry weather seem assured, there is no danger of a subsequent washing. When considered necessary, one will be used. French ocher is used for coloring, and is obtained direct from the importers.

Mr. W. B. Adams is in charge of the small army of painters. This gentleman has had much experience in this class of work and is now engaged in painting the just-completed Kinzua viaduct.

Some sections present many difficulties, and all require constant care and a perfect absence of any liability to dizziness. The painters straddle the cables, working backward. When it is remembered that these cables are about the size of a barrel, and are at a great distance above water level, the operation of reaching under to paint the lower side becomes one of great nicety. The suspender rods are painted by a man swung from the cables. The trusses present no special difficulties. Under the floor beams a stout plank is suspended which is long enough to cover three beams. Six men, one upon each side of each beam, sit upon the plank and work. By this means a man only paints the surfaces which face him. The plank is shifted in a direction parallel to the beams. A close inspection of the work already done failed to reveal a blank spot, clearly proving the thoroughness of the work. In all probability only one coat will be put on this fall.—*Engineering News.*

THE ORIGIN OF WIND-MILLS.

The origin of wind-mills in France is uncertain. During the early part of the Middle Ages no trace of them is found, and it is very probable that the Latins themselves were unacquainted with them. Vitruvius would not have neglected such a subject if they had existed in his time, since he mentions water mills, which had been known from ancient times. We find in the *Dictionnaire des Origines* an agreement dated in the year 1105, by which a religious corporation was given the privilege of erecting a wind-mill. In the National Library there is a curious manuscript, *Le Saint Voyage de Jerusalem du Baron d'Anglure* (1395), in which there are a few lines on the subject under consideration. The Baron d'Anglure minutely describes all the curiosities that he saw in his pilgrimage, and which were numerous. Among other wonders, he saw at Rhodes "sixteen wind-mills all in a row and all near each other, and each having six sweeps."

When, in the fifteenth century, Seigneur de Caumont described, in his *Voyage d'Outtremer en Jerusalem*, the curious monuments that he saw at Rhodes, he said, also, that all along the walls of the city are set XVI wind-mills, all in a row, which, day and night, grind during winter and summer." In the Norman texts, according to Leopold Delisle, there is no record of wind-mills till toward the end of the twelfth century only. They were called "Turkish Mills" in the country. It is for this reason that it is supposed that it was the crusaders who introduced the use of these engines from the East. The preceding citations seem to offer proof of this interesting innovation in our country and permit us to believe that travelers who had returned from the Holy Land made known at home the useful things that they had remarked during their pilgrimage.

The mills of Eupatoria, whose appearance I sketched during my voyage in the Crimea (Fig. 1) may give some idea of these Oriental mills, which "are all in a row, and all near each other." Some are like our own, but the majority have eight sweeps. The occupy the entire suburbs of Kozlof, and offer a most picturesque aspect along the Black Sea.

In the sixteenth century a few mills were observed in France constructed entirely of stone, their mechanism being thus better protected. In Morbihan, very near the small city of Auray, a specimen of these graceful structures may still be seen (Fig. 2).

At Chesterton, England also, there exists a curious stone mill bearing the date 1678. Its plan is circular, and it is supported by five arches. The ground floor is thus open, and the first story is reached by means of a wooden staircase.

Our present wooden mills very nearly resemble those owned by our forefathers in the fourteenth and fifteenth centuries. In the celebrated tapestry plan of the time of

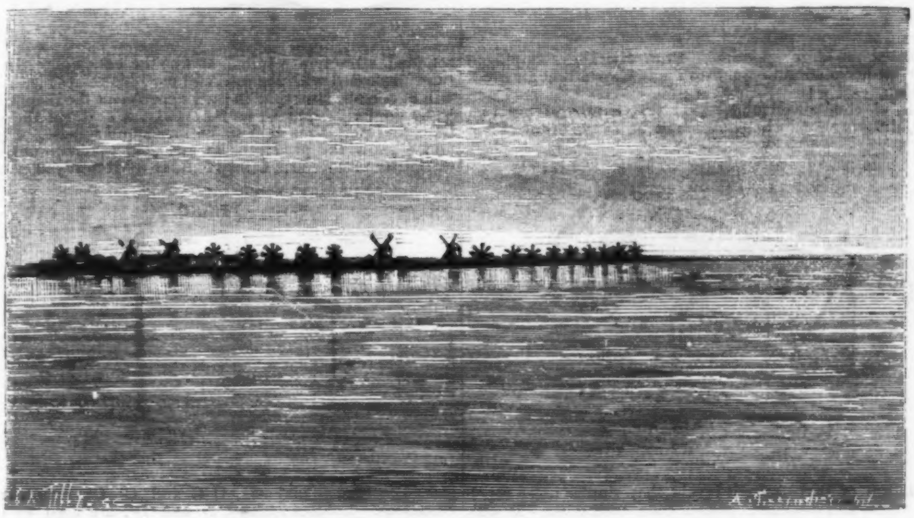


FIG. 1.—WINDMILLS OF EUPATORIA IN THE CRIMEA.

Charles IX. it is seen that Paris was surrounded with them. They existed everywhere; at the Gobelins, at Saint Marcel, at Montmartre, etc., and finally at the Butte des Moulins, now the Avenue de l'Opera. These latter overlooked a hogmarket, and were near the city, by the Saint Honore gate. They disappeared from the hill towards the year 1668, and were removed to Montmartre, Sainte Geneviève Mountain, and other places. One of them was still in existence a few years ago at Crouy-sur-Ourcq, and there was to be seen over the front door of this curious two-century-old monument the rude image of Saint Roch, under the invocation of whom the mill had been baptized.

In the eighteenth century there was still a large number to be seen on the hills of Montmartre, but there are but two of them remaining at present, and the mills of Galette are too well known to make it necessary to give a sketch of them.

FIG. 2.—AN AURAY WINDMILL.

Holland, the land of wind mills, is also losing these picturesque structures from day to day, they being, as in France, gradually replaced by steam engines.

With the possibility of utilizing natural forces by electricity, it may be that wind-mills will again some day find numerous and useful applications. This is what the future is to teach us.—*A. Tissandier, in La Nature.*

WATER GAS AS FUEL.

PROFESSOR VON MARX, of Stuttgart, recently delivered a lecture on this subject before the Wurtemberg Society of Engineers, from which the *Deutsch Industrie Zeitung* makes the following abstract:

The success that has attended the introduction of generator gas as fuel in many branches of industry during the past ten years makes it seem desirable that, where heat is employed in a small way, gas with its numerous advantages might come into use. For small fires, as in domestic operations, heating with gas that is conveyed in pipes promises special advantages, if we consider the trouble of getting and preparing ordinary fuel, the difficulty of lighting it, etc., and when we recollect that domestic fires do not utilize more than 10 per cent., on an average, of the total heat which the fuel burned is capable of producing, while it is estimated that in gas heating more than 80 per cent. is utilized. A cheap fuel gas would have great importance for small industries, because gas motors can be utilized where very little power is required; while a steam engine presupposes a large business. People are becoming more and more convinced of the advantages of gas heating for every-day uses, as shown by the fact that illuminating gas is more and more employed as fuel for heating rooms, for cooking, and for driving gas engines in small trades.

A gas that can be used for heating only can be made considerably cheaper than illuminating gas, since fuel gas can be made from the poorest fuel, while the choice of material to be made into illuminating gas is a very limited one. The proposition that Dr. Siemens made twenty years ago, to supply cities not only with illuminating gas but with fuel gas in a separate system of pipes, was not carried into effect simply because such pipes require a large outlay of capital; for it is well known that in city gas works the piping of the city takes by far the larger portion of the first outlay of capital. Since illuminating gas as such has become a necessity, and since it can serve very well for heating purposes, in recent times, when the importance of gas heating began to be recognized, it was questionable whether special plant for fuel gas would pay. With the development of electric lighting, the relations will change sooner or later.

It is a fact even now that more light is obtained when illuminating gas is used to drive a gas engine which in turn propels a dynamo machine for producing the electric light than when the gas is used directly for illumination. The following table of M. Niaudet exhibits the results obtained by different experimenters in measuring the light that one horse power (75 kilogrammeters) will yield with the most important systems of electric lighting. The results are given in Carcel units:

1.	Voltaic arc, distance of carbons, 10 centimeters (4 inches); maximum numbers not to be reached in practice; ordinary Gramme machine (Fontaine).	585
2.	Voltaic arc, distance 3 c. (1¼ in.), ordinary running; Gramme machine (Fontaine)	230
3.	Voltaic arc; number given by the President of the Committee on Lighting by Electricity, was 2,400 candles (9·6 candles=1 Carcel)	250
4.	Jablochkoff candle; Gramme machine with alternate current; one candle requires five-sixths of a horse power (Honoré), and gives, according to Joubert, 41 Carcels; so that each horse power equals	49·2
5.	Edison's incandescent lamp gives, according to Rowland and Barker	11 to 21
	According to Bracket and Young	19
6.	Swan's incandescent lamp gives 150 candles (9 candles=1 Carcel)	16⅔

A gas motor using illuminating gas consumes, on the average, about one cubic meter (37 cubic feet) per horse power of 75 kilogrammeters (or 542 foot pounds). On the other hand, an Argand burner consuming 150 liters (5 cubic feet) of gas per hour gives a light equal to 18 candles, and a cubic meter of gas will give a light equal to 120 candles; and, reckoning a Carcel burner as being equivalent to 9 candles, this corresponds to 13⅓ Carcels. The numbers in the above table are nearly all higher than this, and more especially those with the electric arc; but even the incandescent lamps can compete with gas. In burning illuminating gas, a comparatively large portion of the chemical energy is converted into heat, and a small portion into light. With the electric light the conditions are far more favorable to the production of light. If the electric light is, for equal intensity of light, already cheaper than gas light for lighting large places, it may be assumed that, owing to the great attention now paid to the subject, it is highly probable that this will soon be the case for small lights too. Illuminating gas will then be superseded, but fuel gas will gain all the more in importance.

If it be asked how a cheap fuel gas can be made, we come to the conclusion that we must follow some other method than that used in making illuminating gas, because only a small part of the fuel is converted into gas by dry distillation. From 100 kilos. of gas coal we get about 28 cubic meters of gas, or 14·4 per cent. by weight, with 66 per cent. of coke, of which 20 per cent. is used in heating the retorts; so that more than 40 kilos. of solid fuel must be sold or disposed of. A process that converts all the fuel into gas is preferable to dry distillation. Propositions for making fuel gas by dry distillation are not lacking; for example, it has been proposed to distill brown coal in the Furstenwald, 24 miles from Berlin, and convey the fuel gas in pipes of boiler iron exposed to the air, and pass it into twelve gasholders in the city, from which it can be distributed to consumers like illuminating gas. Fuel can be all converted into gas by incomplete combustion, such as takes place in the generators in large heating operations. There the carbon of the fuel is converted into carbonic oxide by the oxygen of the air, and for heating purposes this combustible gas is burned to carbonic acid in the heating apparatus. Of the 8,080 heat units which carbon generates by complete combustion, 2,473 are developed in burning it to carbonic oxide—*i. e.*, 30·6 per cent. of the total heat is lost when "current" gas (gas made at a distance and passed through pipes) is used. Then, again, generator gas is rich in nitrogen, which takes no part in the combustion, but helps to cool the flame. In generator gas there is, on an average, 70 per cent. by volume of nitrogen; and by theory (if, for simplicity, one reckons only the carbon) about 66 per cent. It would not pay to carry gas, two-thirds of which was entirely worthless, through a costly system of pipes. Hence it will never do to think of passing generator gas through pipes.

All the conditions are more favorable for water gas. This gas, as is well known, is made by decomposing water by passing its vapor over glowing coal. Every form of carbon can be used, charcoal as well as coke. The carbon takes the oxygen away from the water and sets free the hydrogen. The decomposition of water by glowing coal can take place in two ways; either carbonic oxide or carbonic acid may be produced along with hydrogen. The first takes place when there is an excess of carbon and a high temperature. If the temperature falls, carbonic acid is formed. At about 600° C. (1,112° Fahr.) the carbon begins to decompose the water. In practice both processes go on together. A water gas cannot be made that is free from carbonic acid, but in making fuel gas the problem will be to conduct the process in such a manner that only hydrogen and carbonic oxide shall be formed, if possible in equal portions. In reality, water gas always contains more or less carbonic acid as well as atmospheric oxygen and nitrogen. Theoretically it takes 1·4 kilos. (3 pounds) of carbon to make 3·72 cubic meters (137·6 cubic feet) of water gas, or every pound of carbon should yield theoretically 44⅙ cubic feet of gas. The actual yield is considerably less. In experiments made with Strong's system, in Stockholm, 1 pound of coke made 20·6 cubic feet of gas, or, as the coke left 20 per cent. of ash and dust, a pound of carbon made 25·7 cubic feet of gas, which is 58 per cent. of the calculated theoretical quantity. This small yield is to be ascribed chiefly to the considerable quantity of heat lost in the process, whereby the consumption of fuel coal is much greater than it should be by theory.

If it is asked how far the manufacture of water gas is justified, we must first remember that, theoretically, nothing is gained and nothing lost in the water gas process. The same quantity of air is requisite to burn the carbon as to burn the water gas made from it. The process only serves to convert solid fuel into gaseous fuel, because, in general, greater useful effects are obtained by burning the gas than by burning the solid fuel. On the whole, heat is lost, because the water used in the process must be heated to the temperature of the gases escaping from the chimney, whereby the very considerable specific heat and latent heat of the water comes into consideration. From this it follows that in large heating arrangements a special generator that can be placed near the space to be heated will be better than a water gas furnace; that even the simultaneous admission of steam into the generator must have a bad effect, for in this case none of the heat produced in the generator would be lost if the generator gas entered the heating space directly and had no opportunity to lose its heat. The case would be quite different if the gases produced in the generator could be cooled before they entered the heating space. In this case it would be advantageous to make use of part of the heat developed in the generators for making water gas, which could then reproduce in the space to be heated the greater part of the heat taken up in the generator—*i. e.*, in this case it would be expedient to feed the generator with a mixture of steam and air, so as to produce a mixture of water gas and generator gas.

Water gas offers a decided advantage over generator gas as a fuel gas that has to be conveyed any distance, if we consider the cost of piping. It remains, then, to make the pipe system do the utmost possible service. The greater the heating power of the gas, the better this is accomplished. The heating power of water gas is calculated to be about four times that of generator gas; hence the latter must be left out of account as a "current" or flowing fuel gas, for it will not do to convey the 70 per cent. of inactive nitrogen in generator gas through a costly system of pipes. All that has been said in favor of water gas as compared with generator gas can also be said in favor of ordinary illuminating gas as compared with water gas, since the former has nearly double the heating power of the latter. Hence the cost of making water gas must remain considerably less than half that of coal gas, if it is to compete with the latter as a fuel. This is, however, possible, because the very poorest fuel can be used for making water gas, and all the material is converted into gas and in a manner requiring much less labor, and with much cheaper and more efficient apparatus, than for coal gas. Perhaps it would pay even now to set up water gas generators (gasogens) by the side of retort benches, so as to

make carbureted water gas, which can be made as luminous as the best coal gas, and then could be mixed with it.

To see what one water gas generator is capable of doing, we must consider that a coal gas retort may be assumed to make 150 cubic meters (5,550 cubic feet) in 24 hours, and in the experiments made at Frankfort with a water gas furnace 2,500 cubic meters (92,500 cubic feet) of water gas were made daily; so that its production corresponds to that of 17 retorts. According to Quaglio, such generators can fill the place of as many as 60 retorts, and the greater their production the cheaper they work.

If water gas can be made cheap enough, of which there can scarcely be any doubt, and if the future gas lighting is to yield to electric lighting, illuminating gas will still not be entirely dispensed with. Then the fuel gas could be carbureted with petroleum naphtha in suitable carbureters by the consumers themselves, and thus be converted into an illuminating gas on their own premises.

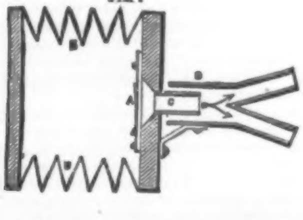
Owing to the large percentage of carbonic oxide that it contains, water gas is very poisonous, and so is common illuminating gas. The latter, however, has the very valuable property of smelling so strongly that 1 part in 10,000 of air can be recognized by the odor. Water gas, on the contrary, has scarcely any smell. The proposition that has been made to remove this objection by mixing some strong smelling vapors with the water gas would not present any very great practical difficulty.

From the foregoing it will be seen that under certain circumstances water gas has its legitimate uses, and hence it has a future. In a limited sense it can be justly designated as the "fuel of the future."

MECHANICAL VIBRATIONS AND MAGNETISM.

MANY men believe the universe to consist of motion and matter, and they hold, says the *Engineer*, that all natural phenomena whatsoever depend upon these two things for existence. Those men who have made a study of electrical subjects, whenever they speak of their studies or electrical phenomena, are always guarded in giving an answer to the question, What is electricity? Some, however, say it is matter, others that it is motion. Future generations may, perhaps, know for a certainty what it is, but at present there

FIG. 1



is no such certainty. From time to time interesting investigations are made, and a glimpse is caught of the great unknown. This is so in the case of those able experimentalists who have been comparing mechanical vibrations, and the results obtained in certain directions therefrom, with certain magnetic phenomena. We have long intended to describe the experiments of Professor Bjerkness as shown at Paris, but more immediately important matters have from time to time delayed such description, and now our notice of these experiments may be given in conjunction with a report of another paper which details experiments

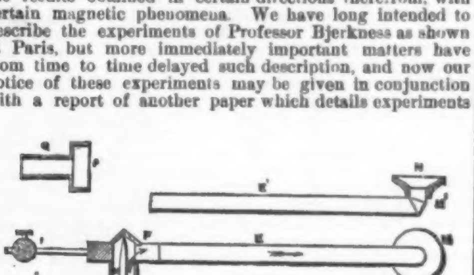


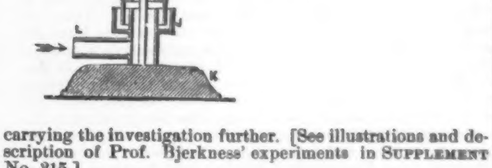
FIG. 2

carrying the investigation further. [See illustrations and description of Prof. Bjerkness' experiments in SUPPLEMENT No. 315.]

Mr. A. Stroh, who has long been known as one of the deftest of mechanists, and combining with this ability a faculty for experiment of the first degree, in a paper recently read before the Society of Telegraph Engineers has described a series of experiments by means of which he has been able to compare mechanical and magnetic phenomena.

Professor Bjerkness has shown that the vibrations of

FIG. 3



water cause similar phenomena, so far as attraction and repulsion are concerned, to those which occur under magnetic action. Tubes ending in one direction in a drum, in the other in pipes conveying air, are placed by Professor Bjerkness in water and under the action produced by alternately extracting and sending in air, peculiar phenomena are produced. Mr. Stroh, like many others, was exceedingly interested by these experiments in Paris, and subsequently determined to carry out a series of experiments himself. These experiments were repeated before the Society, and so interesting did they prove that Mr. Stroh has promised to again deliver his paper and show the experiments at a special meeting to be held within the next few days. No doubt advantage will be taken to hear and see what has been done. Meanwhile we shall indicate the character of the experiments shown. The illustrations we give may be taken as correct, as much of the apparatus was

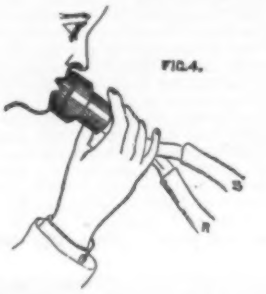


FIG. 4.

delineated on large diagrams. Prof. Bjerkness employed water as his medium; Mr. Stroh has shown that air gives excellent results.

It is of course well understood that a magnet has two poles, differing somewhat, inasmuch as in the ordinary no-

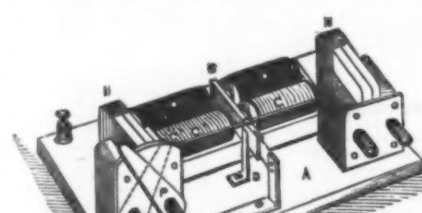
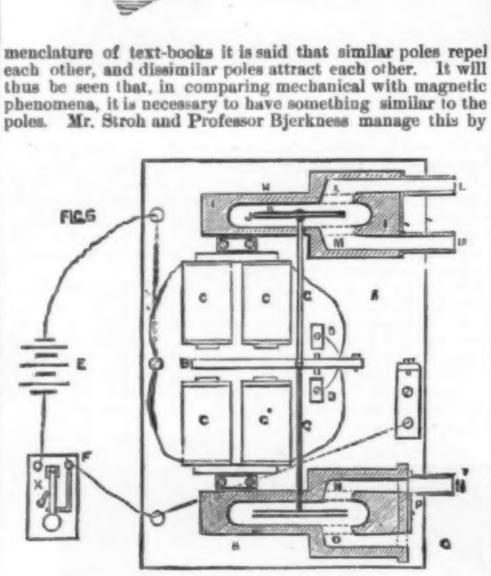


FIG. 5

menclature of text-books it is said that similar poles repel each other, and dissimilar poles attract each other. It will thus be seen that, in comparing mechanical with magnetic phenomena, it is necessary to have something similar to the poles. Mr. Stroh and Professor Bjerkness manage this by

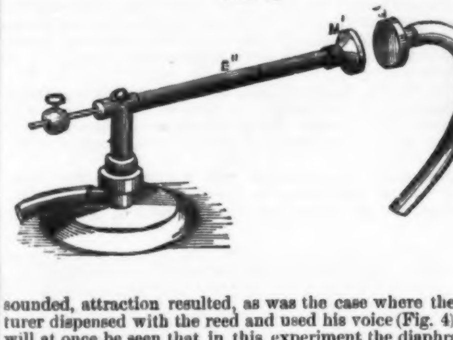
FIG. 6



using India-rubber diaphragms like drum-heads, the drums being connected with the pumping apparatus. In order to obtain similar action, Mr. Stroh splits his air channel into two, like the arms of the letter V; the shank, say, being in connection with the air pump—the arms connected to two drums. These connections allow of similar action of the diaphragms of the two drums. The first experiment will now be understood. In Fig. 1, A shows a vibrating reed, actuated by air bellows, B, the aperture over which, A, is placed terminating in the short tube, C. A larger tube, D, is placed over C, and has two branches, on which flexible tubes are placed to communicate with the apparatus shown in Fig. 2. This consists of a light tube, E, fitting on the nozzle F, which forms part of the tube, G, which rests on a steel pin, H, by means of a cup. A weight, I, counterbalances E; J is a mercury cup, into which one end of G dips; L is for the connecting tube. This apparatus conducts the vibration, and at the same time may be revolved on the pivot. The drums, M M^1, carry diaphragms at N and M.

The connecting tubes are shown in Fig. 3. When the diaphragms were brought opposite to each other, and a note

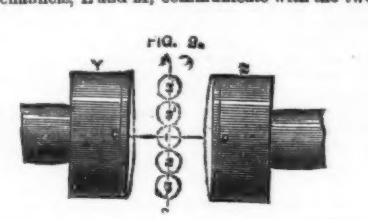
FIG. 7.



sounded, attraction resulted, as was the case where the lecturer dispensed with the reed and used his voice (Fig. 4). It will at once be seen that in this experiment the diaphragms acted similarly—that is, both bulged out or in at the same time, and were thus said to be in a similar phase. Figs. 5 and 6 show the apparatus as arranged to obtain unlike or dissimilar phase. On a board, A, is a vibratory iron armature, B. Electro magnets, C C and C^1 C^1, maintain the vibrations. Contact springs, D and D^1, are used to close alternately two circuits while B is vibrating. E is the battery. One electro-magnet and one spring, however, are found to be sufficient to maintain the vibrations. A contact key, F, is convenient to start and stop the vibrations, the handle of which can be held by X. The rods, G G^1, communicate with air pumps, H and H^1. H is made of two hollow blocks of wood, the cavity being divided by a thin leather diaphragm clamped between the two halves of the box, I. Disks of cardboard, K, strengthen the diaphragm. Two air channels, L and M, communicate with the two parts

FIG. 8.

FIG. 9.



of I, and end at L^1, M^1, where the connecting tubes can be fixed. H^1 has only one communication, the end being fixed on a brass lever, P, Figs. 5 and 10, so that it can be shifted to or connected with either of the other ends. It is obvious that a movement of B in the direction of the magnet, C, will cause air to be expelled from the air passages, L and N, and at the same time to be sucked in by M and O, and *vice versa*.

The phenomena of attraction and repulsion were shown in the most complete manner, and it was also shown that merely the approach of a body, such as a piece of carbon or a tracer,

FIG. 10.

near to the diaphragm of one tube, caused it to be attracted just as a magnetic needle is by soft iron. The tube in Fig. 2 may be straight as in Fig. 7. There are various ways of making the drums and of obtaining similar results, which it is not necessary to do more than mention. It may be said here that, according to Mr. Stroh's description, the phenomenon of attraction due to vibrations is comparable with the magnetic phenomenon of repulsion, and the mechanical repulsion with the magnetic attraction—that is, when the diaphragms vibrate similarly or in the same phase, attraction results; when they vibrate dissimilarly, repulsion takes place.

In the experiment next described the drums were fixed.

The apparatus is shown in Fig. 11, and is almost the same as in Fig. 10, except that the board, S, replaces the balance. This board has two brass uprights, T T', supporting by friction the brass tubes, U U', the outer ends of which are connected with the flexible tubes, R and S, while drums, Y and Z, are fixed to their inner ends. Taking a light cork ball, C, suspended as shown in Fig. 8 on a light rod resting on a pivot, it will be in certain positions attracted and repelled. Fig. 9 shows the drum as seen from above, and if the back is placed so as to move in the line, *a b*, it is attracted when the diaphragms vibrate in opposite phase to the central position, 1; while when vibrating in similar phase it is attracted to 3 or 3'. This experiment is analogous to one of Dr. Bjerknees' with a small piece of iron and bar magnets, the iron being placed on cork and floating in water. Thus far Mr. Stroh explained that he had followed and corroborated Professor Bjerkness, but his intention was to direct attention to phenomena which, while recognizable when the medium used was air, might be overlooked when the medium for carrying or transmitting the vibrations was water. The lecturer wanted to ascertain what the mechanical movements of the air were which cause this attraction and repulsion. The pole of a magnet, as is well known, causes some changes in the material in its immediate vicinity, and, in fact, causes what is termed a magnetic field, the entrance into which of metallic bodies induces certain phenomena to take place, such as in the case of a piece of iron becoming magnetic, or that of a wire moving through different parts of the field of an electric current. Similarly the vibrating diaphragms cause changes in their immediate neighborhood. These changes can be investigated as regards direction and amplitude like any other forces, and Mr. Stroh's investigations have shown to him that the diagrams of the lines of vibrating force were very similar to the diagrams of the lines of magnetic force, except that the former were extremely feeble at a short distance from the diaphragms. The direction and amplitude of the vibrations were ascertained by means of a gas jet, the flame of which follows the vibrations of the air, and viewed from above its more luminous upper part forms straight or curved lines. [The diaphragms in Figs. 3 and 10 should not be connected, as incorrectly shown in the engravings.]

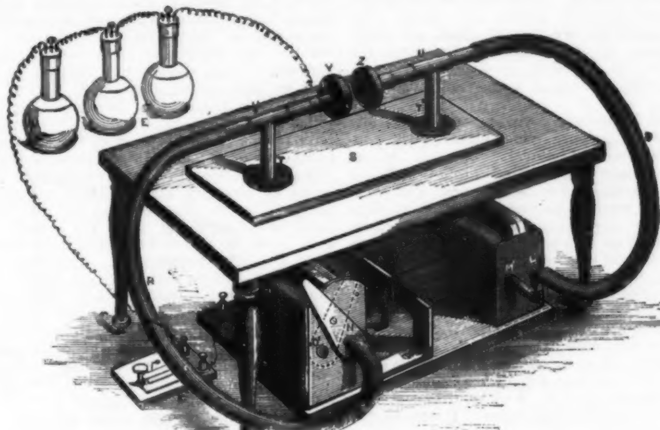


FIG. 11

THE PENTANE PHOTOMETER.

In this photometer, a special gas is made to take the place of the sperm candle, with satisfactory results, as an absolutely correct standard light can be obtained, which is not the case with the variable sperm candle. We may observe that pentane is a liquid obtained from American petroleum. The photometer has no moving parts, as is the case in most other photometers. It consists of a table, on which are fixed, at appropriate distances, the gas-testing burner, the pentane gas-burner, and the screen, which has a square opening, over which translucent paper is fastened. The leading features are that the gas is standardized by determining how much must be consumed to give the required result of sixteen candles, and that the standard is not a candle, but a definite mixture of the vapor of pentane and air. This mixture is burned through a specially-constructed burner, which consists of a brass tube 4 inches long and 1 inch in diameter, terminating by a disk half an inch thick with a quarter of an inch hole in the center. It is surrounded by a short glass chimney, terminating at its upper extremity, a little below the top of the burner. Instead of correcting his readings of gas consumed by referring to the barometer and thermometer, the observer notes the volume occupied by a standard quantity of air by means of a little instrument, which Professor Harcourt has named an aerorthometer, and to which we shall again refer.

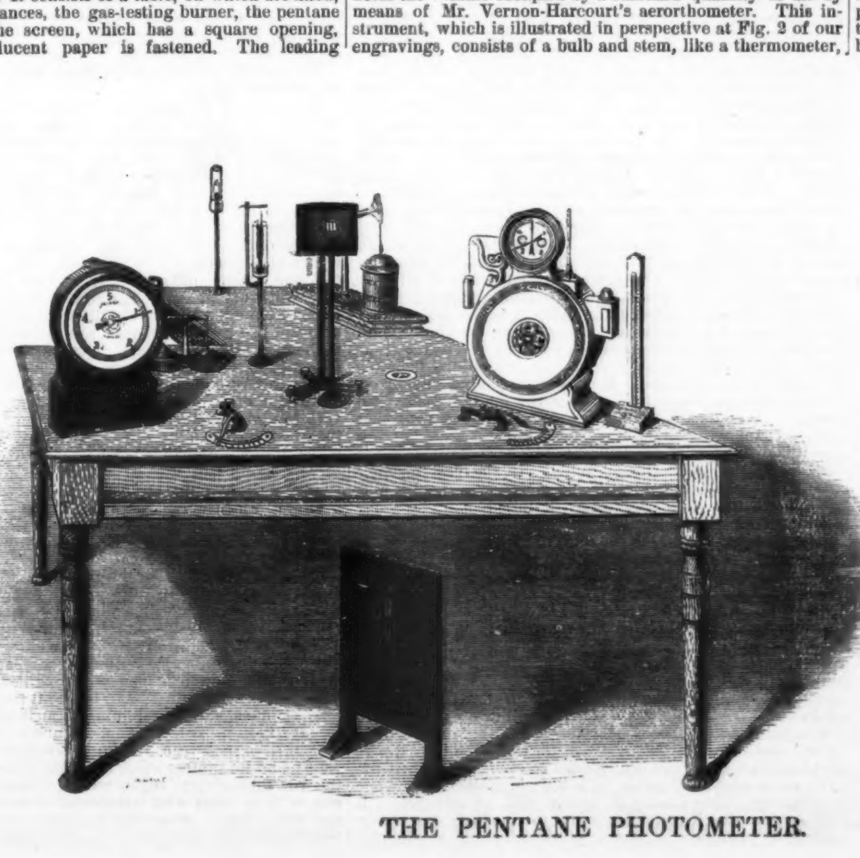
It will be seen that this apparatus is based in principle entirely on the evenness of the illumination of a small sheet of tissue paper, and is, therefore, to be classed with those that are known as shadow photometers. The opaque screen, which has in it a square aperture, over which prepared paper is fastened, is fixed to an upright standard on the table. At a distance of one foot from this screen, and at a small angle to the left, from a perpendicular from the center of the screen, is fixed the support which carries the pentane burner. At the same angle from the perpendicular, but off to the right hand and at a distance of four feet, is the Argand gas burner, also fixed to the table. On a loose support is fixed a square metal screen, which is provided with two vertical openings, which have a strip of metal between them. This is so placed between the prepared paper and the lights that the pentane flame illuminates the right and left of the tissue paper, and the gas flame illuminates the intervening portion, or *vice versa*. The air-gas is then adjusted to exactly its correct rate of consumption, and the gas is slowly turned on until the tissue paper is equally illuminated. The consumption of gas during one minute is then recorded. The gas is then turned up so as to give too large a flame, and is then slowly turned down until there is no longer in the middle of the paper a bright or dark band, as the case may be. Another observation of a minute is then taken, and the mean is taken as the result. The principle on which the gas is tested is the following: Given the amount of light required, determine how much gas must be consumed to produce the result. As it is extremely difficult to completely eliminate bias, Mr. Harcourt adjusts the gas by means of a small lever working over a quadrant. After adjusting the light with an increasing flame, a small recording plate is moved to indicate the position of the lever. This plate is only flush with the surface of the quadrant, and, therefore, offers no resistance to the free movement of the lever.

We have stated that with the pentane test the observer notes the volume occupied by a standard quantity of air by means of Mr. Vernon-Harcourt's aerorthometer. This instrument, which is illustrated in perspective at Fig. 2 of our engravings, consists of a bulb and stem, like a thermometer, containing air inclosed over mercury. The mercury stands at a certain height in the stem, and rises and falls as the inclosed air contracts or expands with changes of temperature and atmospheric pressure. The volume of the air is read off by means of a scale engraved on the stem and on the wood behind it. Each degree of the scale marks a portion of the stem, whose capacity is one-thousandth part of the volume of the inclosed air when under a pressure of 30 inches of mercury and at a temperature of 60° Fahr. The line at which the mercury stands under these conditions is figured, accordingly, 1,000, and any other reading of the instrument, at a different pressure or temperature, gives the volume to which the thousand volumes have been expanded or contracted. A small drop of water having been passed into the bulb, the expansion caused by a rise of temperature includes that due to the increased tension of aqueous vapor. In order that the volume of air inclosed in the bulb of the aerorthometer may be measured under the atmospheric pressure, a second tube is placed by the side of the graduated stem, which is of the same caliber and connected with the same reservoir of mercury, but open above. By the pressure of a screw upon the leathern top of the reservoir the mercury is raised in both tubes; and when the mercury stands at the same level in both, the inclosed air is under the atmospheric pressure. By being painted white the bulb is protected from the action of radiant heat. Since the volume of any portion of gas contained in a holder, or passing through a meter near which an aerorthometer is placed, bears the same relation to the volume the gas would occupy under standard conditions as the volume read on the stem of the aerorthometer bears to 1,000, the figures expressing the correct volume of the gas may be obtained by multiplying the observed volume by 1,000 and dividing it by the aerorthometer reading. If n represents the number read upon the instrument, v the observed volume or rate of passage of the gas, and V the corrected or normal volume, then $V = v\frac{1000}{n}$. We should add that the manufacturers of both these instruments are Messrs. W. Sugg & Co., of Vincent Works, Westminster, who also show them at the Crystal Palace Exhibition.—*Iron*.

THE PHOTOMETRY OF THE SUN AND OTHER INTENSE LIGHTS.

According to some recent observations of Sir W. Thomson upon photometric measurements in general, the Carcel lamp standard, as used in France, is more reliable than the English standard candle only because of the careful method and laborious precautions taken to insure its accuracy. In Sir W. Thomson's opinion, if something akin to the precautions applied to the Carcel lamp by Regnault and Dumas were applied to the production and use of the standard candle, sufficient accuracy for most practical purposes could already obtained by the use of the Carcel lamp. With regard to approximative measurements, Sir W. Thomson considers the Rumford shadow photometer the most convenient method for general use. He believes that ordinarily healthy eyes are usually quite consistent in estimating the depth of shadows, even when of different colors, and that with a reasonable amount of care, accuracy within 2 or 3 per cent. might be obtained in photometric measurement by this method. The difference in color of the two shadows of the Rumford arrangement is due, of course, to each shadow being partially illuminated by the other light. In this way Arago had estimated the luminous intensity of the sun as being 15,000 times more than that of a candle flame. Sunlight in Glasgow has been observed of such brilliancy that the amount of it coming through a pinhole in a sheet of paper, only 0·09 centimeter in diameter, gave a light equal to 126 candles. By cutting a piece of paper of such a size and shape as just eclipsed the candle flame, and measuring its area, Sir W. Thomson found that the corresponding area of the flame was about 2·7 square centimeters, or about 420 times the area of the pinhole. From these data he calculated the luminous intensity of the light from the sun's disk was equal to 53,000 candles for equal areas, or more than three times Arago's estimate.

In the last issue of the *Comptes Rendus* appears a "Note" by M. Crova, on the subject of solar photometry. This physicist has already demonstrated that the relative intensities of two lights of different colors may be exactly obtained by the photometric comparison of a simple radiation conven-



THE PENTANE PHOTOMETER.

lently chosen from the spectra of the two sources to be compared.

Upon this principle MM. Crova and Lagarde have compared simple radiations in the spectra of the sun and of the standard Carcel lamp. It was found that a solution of perchloride of iron absorbed the more refrangible rays of the spectrum; so that, by increasing the depth or concentration of this solution, a black screen could be made to spread over the spectrum from the violet end, stopping in any desired region. A similar effect at the other end of the spectrum was produced by a solution of chloride of nickel. Consequently, by suitably mingling these solutions, a yellowish green mixture was obtained, which, when interposed in the path of the beam of light to be examined, only allowed the passage of a narrow luminous band. The color of the sun and of a Carcel lamp, viewed through this medium, is exactly the same. The light of the sun being reduced to a calculated extent by filtration through roughened glass, was then compared in a Foucault photometer with the standard Carcel. An observation taken at Montpelier, at 10 A.M., with a clear sky, gave a solar intensity of 56,070 Carcels. The corrected intensity of sunlight, with a perfectly clear sky, is therefore calculated to be equal to about 60,0 0 Carcels. This figure signifies that the light of so many Carcel lamps, or of 570,000 standard candles, concentrated in a point at the center of a sphere of 1 meter radius, would give at this distance a luminous field equal in intensity to that of the sun's disk reflected by a mirror at the earth's surface. It is interesting, as affecting Sir W. Thomson's recent determination of the value of sunlight, previously referred to, to observe that M. Crova denies the possibility of measuring photometrically two lights of different colors. He maintains that under such circumstances the retina receives impressions differing so greatly that alternative unequal contractions of the pupil are the result, which again cause errors of comparison. He says that the intensity of the most powerful electric lights may be measured by similar means to those adopted in the experiment just described, although the rays suitable for comparison, and consequently the mixing of the two solutions, will be slightly different.—*Journal of Gas Lighting.*

HEAT, LIGHT, AND ELECTRICITY: ARE THEY EXPRESSIONS OF THE SAME FORCE ?*

By Professor ELISHA GRAY.

IN the short time allotted me for discussing a subject so vast as the one before us to-night, it will be impossible to give it more than a cursory presentation. It is one that has puzzled many older, and, I was about to say, wiser heads than ours of this generation; but I am not one of those who believe that wisdom died with the old philosophers, and that we are simply echoes of a past age. They *were* great men in their time, and towered high above the rank and file of their generation; but we can imagine that even Newton, with his emision theory of light, or Franklin, with his fluid theory of electricity, would either of them cut but a sorry figure among the thinking scientific men of to-day. In this age of lightning, steam, and printing, of school-houses and school-teachers, of reading and travel; this age when all the world are within speaking distance of each other, the man who outstrips his neighbor must be something more than a mere echo.

But to our subject: We have to deal to-night with what are called imponderable forces or energies of nature—heat, light, and electricity. What relation do they bear to each other? Are they expressions of the same force? I confess to having a strong feeling in favor of the affirmative side of the question; a feeling that has grown stronger with each year of study upon this and kindred subjects, until from my standpoint it has ceased to be a speculative question. But now comes the most difficult part of my task. It is easy, perhaps, for us to see from our own standpoint, but how can we make others take the same view that we do? To do this we must first give him the same experience, the same surroundings, the same opportunities, and he must have the same characteristics or qualities of mind. There is a vast amount of unexplainable evidence that presents itself to the mind of the individual, but this he cannot submit to a jury outside of himself. When, however, he makes up his case, he puts this intangible, so to speak, beside the tangible and renders his verdict from the sum of all kinds of evidence before him. We must content ourselves then with presenting a few of the most striking evidences of the correlation of these forces.

First, we must have a clear idea in our minds of the definition of force. What is it? Faraday defines it as "the cause of a physical action; the source or sources of all possible changes among the particles or materials of the universe."

Some writers call it energy and class it under two heads, energy of motion and energy of position; or, as Clerk Maxwell calls it, kinetic energy and potential energy. The bent bow is an example of energy at rest or potential energy; but when the string is released it becomes kinetic or moving energy, and sends the arrow into the target. A weight, when elevated, possesses potential energy; but when released this immediately becomes kinetic or moving energy during its passage to the earth. A lump of coal possesses energy at rest; but when we put it under the boiler of a locomotive, and apply the match, this sleeping energy is aroused and a railroad train is sent flying across the continent.

Energy or force is again subdivided into mechanical, molecular, and radiant energy. Our subject to-night deals more especially with the two latter forms. By mechanical is meant a movement of the mass, as the turning of wheels or the movement of anything, or that which *tends* to the movement of any material thing as a whole, however small, so long as we consider it a movement of a mass of atoms and not of the atoms or molecules themselves independently.

By molecular energy we mean the movement of the molecules of which the mass is made up; movements that are independent of the mass.

In a former lecture, to give a conception of the difference between molecular and mechanical motion, I used the following illustration: "Some of you may have seen a new swarm of bees as they go out of the old hive to seek a new home. They will light on some object near the old hive, perhaps the limb of a tree. Instead of spreading themselves around over a large surface, they will light one upon another until they have formed a mass of bees as large as a cannon ball. Looking at this mass as a whole, it seems to be quiet, but if you examine it closely you can see that each individual bee is in motion. This individual motion will represent the molecular motion of the mass. Now, suppose these bees to be so small that it would require fifty millions of them ranged in single file to occupy the space of a linear inch. Then let us get together enough of them to make a mass as large as a cannon ball, and we have some conception of molecular motion as distinguished from mechanical or visible motion. But you ask, how can these molecules move when they are bound together? The theory is, that all space is filled with a very subtile form of matter, called ether. It is everywhere present and pervades all masses of matter, even the most solid. It surrounds every molecule and every atom in the universe, so that all the countless worlds are afloat in this subtile fluid, not only as masses, but as molecules and atoms of which they are made up. No one of these actually touches the other, but is surrounded by the subtile fluid, so that each atom and molecule has its own little orbit of motion."

Having described the difference between mechanical and molecular, let us now consider the last of the trio, and ask, what is *radiant* energy? I have alluded to the theory of the existence of an ether, so subtile that it pervades all space, even the intersellar spaces surrounding the molecules of all masses of matter. I here use the word space and matter in the ordinary sense; for, considering the hypothetical ether to be a very elastic form of matter without sensible weight, there is no such thing as space or vacuum. Although we may expel all the coarser or sensible forms of matter, and make what is commonly called a vacuum, we cannot expel the ether. We are in the dilemma of the man who invented the universal solvent. He did not dare to make any of it, because, *being* an *universal* solvent, of course nothing would hold it.

You may ask, why is it necessary to assume that there is such a fluid as an ether? Because we cannot separate energy from matter. We cannot conceive of force acting upon nothing. We cannot conceive of motion without something to move. Assuming for the moment that heat and light are modes of motion, we must admit that there exists in the vast space between us and the sun some medium through which the vibrations of heat, light, and other forms of force are transmitted, for it is proved that, at most, the atmospheric envelope surrounding the earth is only a few miles deep. The so called forces, such as light, magnetism, and radiant heat, are transmitted through this subtile fluid which for want of a better name we call ether. Force thus transmitted is called radiant energy.

Great confusion often arises from the misuse of words. We say heat is force, and that heat is a mode of motion. In other words, we say force is motion. Now motion is simply a change of position of a material substance. It may be the atom, or it may be the mass. Force is the cause of that change. We cannot conceive of motion existing independent of force, but we can conceive of force without motion in the form of potential energy.

If a weight is suspended by a cord, there is a force tending to break the cord equal to that required to elevate the weight. And the moment the resisting force of the cord is overcome, that force produces motion.

Matter is wholly inert and has no inherent power to move; I am aware that there is difference of opinion on this point, but I fail so far to see any evidence of an inherent power in the atoms of matter to move. What, then, is force? As we said before, it is the ability or the tendency to produce motion in matter, or to do work. Where does this ability come from? This question is quite as easily answered as how the atoms became possessed—if they were possessed—with an inherent ability to move. But who can answer either question?

We know that force exists, and its effect upon material substances differs greatly under different circumstances.

After all, is there more than one force? We speak of the forces of nature, and classify them as heat force, light force, electric force, etc. Should we not speak of the force of nature as exhibited in heat, in light, in electricity, etc.? You ask, if there is but one force, why does it not always manifest itself in the same way? Simply because the conditions are different at different times and in different places. The same force applied to different materials produces different results. If I apply a red hot iron to my finger, I blister the flesh and cause great bodily pain; but if I apply the same heated iron to the face of a thermo-electric pile, I produce no mechanical injury to it, but I do set up a current of electricity which will be able to give mechanical motion to the armature or needle of an electro-magnetic instrument placed in its circuit. Again, I apply the same red hot iron to a loaded cannon, the powder ignites, and the ball is sent whizzing through the air. Now, all of these effects were the result of applying the same force in the form of heat to different materials. In one case it made a blister attended with pain, in another it created a current of electricity, and in a third it fired a cannon. I have here some mounted tuning forks. Two of them are made as nearly alike as possible. I place them some distance apart and apply mechanical force to one of them by drawing this bow across it until it is thrown into violent vibration. These vibrations move all the air in the room, and not only the air but all the furniture and even the walls. The tympanic membranes of all your ears are thrown into sympathetic vibration, which is communicated to the brain through the auditory nerve, and you say that you hear a musical tone. I now check the vibrations of the fork that had the force applied to it, but you still hear the tone. The other fork has taken up the vibrations from the air and prolongs the tone. Here is still another fork in all respects like the other two, only in the matter of size and weight. I apply the same force in the same manner, and you have the result; you hear again a musical tone, but you say it is different. I stop it, but the tone is not prolonged as before by the other fork. Why? In the first instance the forks were tuned alike, and each was only able to vibrate, as a whole, three hundred and forty-one times per second. They being in exact accord, the vibrations set up in the air by the initial fork were able to cause the other to vibrate in unison with it. The last fork had the same force applied and in the same manner, but as you have observed, the result was different. This fork is shorter and lighter, and by a fundamental law of matter is able thereby to vibrate at a much higher rate of speed, producing a tone of higher pitch.

This statement may seem to conflict with what I have said about all the furniture in the room vibrating when the forks were sounded. All solid bodies have two kinds of vibration. When a body vibrates as a whole, we call that its fundamental or natural rate; but it may break into nodes or neutral points and vibrate in parts; hence, the vibration imparted to the furniture and walls is a species of molecular vibration. The fundamental vibration of a body is excited only when a vibration exists exactly in accord with its own rate. It will be seen that it is not necessary to conclude that every different expresion of force proceeds from a different cause; it seems to me not only not necessary, but unphilosophical.

Let us consider for a moment force as expressed in vibrations. To go back to the tuning fork, suppose we have one so long and large as to be able to vibrate only at the rate of eight times per second. These vibrations would be so slow and sluggish as to be seen by the eye, but not heard by the ear. Now take a smaller one. That has a fundamental rate of thirty-two vibrations per second. The eye will scarcely be able to see them, but the ear will hear them as a very low bass note. From this point, we make our forks smaller and smaller through the whole range of tones up to about forty thousand per second, where the vibrations cease to make an impression as sound. Here we pass from what we have styled mechanical to molecular vibration. We have increased the rapidity of the vibrations until the ear can no longer hear it as sound. But the vibrations now appeal to another sense—that of feeling.

Suppose we take a metal rod and apply force to it by striking a few blows on the end with a hammer. The result of the blow is a violent vibration of the atoms set up in the rod, and we have molecular vibration, and it manifests itself in the form of heat. This kind of motion does not affect the sense of hearing. In the case of the tuning fork, the brain receives the sensation of sound through the medium of the auditory nerve. In the case of the metal rod, the brain receives the sensation of *heat* through the nerves of sensation. Both of these sensations are the result of the application of the same force. Both sensations proceed from vibrations differing in rapidity. They may or may not differ in form. Let us now stimulate this molecular excitement by the application of additional force, either mechanical, electrical, or heat force. When the atoms have reached a certain stage of vibratory action, they become incandescent and emit luminous rays or force in the form of light. This vibration is so rapid that it cannot be propagated by ordinary matter. It is not sufficiently elastic to carry vibrations that travel at the rate of one hundred and eighty-eight thousand miles per second, and here we fall back upon the before mentioned hypothetical ether as a medium for light transmission. This ether is capable of transmitting vibrations that differ greatly in rate. For instance, the color of the lowest pitch as shown by the spectrum, is deep red; its vibration frequency is four hundred million million times per second, and its wave length in air is seven hundred and sixty millionths of a millimeter. Further down the spectrum, after the lines have ceased to be luminous, we find heat vibrations of a much less number per second. The color of highest pitch is violet, which is the highest line of light in the spectrum. This has a vibration frequency of about seven hundred and sixty million millions per second, and a wave length of four hundred millionths of a millimeter.

Color, then, like sound, is considered subjectively, a sensation produced upon the brain by rapid vibrations impinging upon the retina of the eye. The difference of color is caused by difference of rate precisely analogous to difference of pitch in musical tones; and there is about an octave of colors. The range of vision is not so great as that of hearing. The range of vision and of hearing differ greatly with different individuals. Some persons are *color* blind, and some cannot hear tones as high in the scale as others. In the former case there is a defect in the retina or optic nerve, so that it is incapable of transmitting the vibrations of a particular color to the brain, and in the latter there is a defect in the auditory apparatus. The force may exist, but the machinery is defective and will not respond to it.

If we take a strip of steel and polish it so highly that it becomes a perfect reflector, it will have a white appearance because it reflects all the colors equally. Now, if we cut fine scratches in it, too fine to be detected by the sense of touch, there will first appear a violet band of color corresponding to the top or most refrangible line of the spectrum. Besides this band let us cut another series of lines, a little deeper; when the length of the scratches corresponds to the wave length of the vibration, which causes the sensation of blue, that color will be reflected to the exclusion of the other. Going on down the scale and cutting lines a little deeper for each band of light, we bring out all the colors of the rainbow. What have we done? We have simply cut a series of fine lines across the metal strip, the depths of which correspond to the wave lengths of the color vibrations, so that they are only able to reflect the vibrations whose length corresponds to their depth.

We see all objects, except those that are *self*-luminous, by reflected light.

The color of an object is determined by the shape of its surface. A piece of white cloth reflects all the colors about equally; the resultant effect upon the brain is white. If we dye that piece of cloth violet, what have we done? We have saturated the cloth with a pigment whose surface structure has indentations four hundred millionths of a millimeter in depth, so that it is able only to reflect the vibration causing the sensation of violet upon the brain. All the other rays are absorbed by the cloth, and appear as heat. The other colors are brought out in the same way, so that objects of different colors differ simply in their surface structure. Different tints of color, like sound tints, or quality, are obtained by the mixture of the different rates of vibrations in different proportions, as they are reflected from the object to the eye. In other words, it is the ability of the object, owing to its surface structure, to reflect to a greater or less degree any combination, or all, of the color vibrations.

Newton's theory of light was that it was an emanation of very fine luminous material. In the light of the present day this theory has so many objections that it seems hardly worth while to spend time to combat it. Yet there are some writers of very recent date who have gone back to this theory, both as regards light and sound. It is easily proved that sound depends for a medium of transmission upon some ponderable substance of considerable density. If we put a ringing bell under an exhausted receiver, the sound ceases, but as soon as we admit the air, it becomes audible. If it contained the elements of propagation within itself, the removal of air ought to facilitate its transmission. Owing to the fact, however, that our so-called vacuum is still filled with ether, the removal of air does not interfere with the transmission of light, heat, or magnetism. The well-known incandescent electric lamp shines through a *vacuum*, so far as air is concerned. The sunlight comes through millions of miles of vacuum, as we understand it, before it reaches the earth. If light is an emanation of luminous material, we ought to see it anywhere in space. A well-known experiment proves that this is not true. Take a straight tube of sufficient length and let another cross it so that you can look through the first tube at right angles with its length. Coat the inside of these tubes with lampblack, so the inner surfaces will not reflect light. Place this in a dark room, letting one end run through into the light of another room, or out of doors.

* Lecture delivered before the Chicago Philosophical Society, Feb. 3, 1883.

Direct a strong ray of light through the tube, and a bright spot will appear on a screen in front of the inner end.

Now, if light was simply an emission of luminous particles, we should be able to see the beam as it passed through the cross tube. Upon looking through the cross tube, which passes directly through the beam, no light is seen; showing that it is only luminous when it strikes some material substance capable of reflecting it to the eye. If we could be shot up into space a million or two miles from the earth, or from any planet, the earth would look to us like the moon or one of the stars; and while we could *see* the sun, moon, and stars, we would be in comparative darkness The space between the planets and stars would be black as night. There would be such a small material reflecting surface that the sensation of light about us would be very small as compared with that at the surface of the earth. The reason why it is so light to us down here is, that there is such a vast reflecting surface which diffuses the light in all directions. The atmosphere plays an important part in the reflection and diffusion of light. Who has not observed that the light is brighter on days when there is a little haze in the atmosphere and when the sky is partly covered with clouds which act as reflectors of light? Who has not observed that a *very* clear, cool day, such as we have sometimes in early summer or in the fall, when no trace of cloud or haze is to be seen, that notwithstanding the air is exceptionally clear, it does not seem so light as when *not* so clear. As a matter of fact, it is not so light, on account of the absence of the before mentioned reflectors.

Having given some idea of the physical character of light and heat, let us now pass for a moment to the consideration of that expression of force called electricity.

Force is transmitted electrically with far greater speed than by any other known process where a ponderable material is the medium of such transmission. Its speed, however, does not compare with that of light or radiant heat through an ordinary conductor, but it is incomparably greater than heat when transmitted by the molecular process, that is, by the impact of one atom against another consecutively.

There is no standard rate of transmission for electricity, as it varies greatly according to the quality of the conductor. Under some circumstances its speed may be as great as that of light or even greater.

Perhaps there is no branch of science that so baffles the student as electricity and its nearest of kin, magnetism. Owing to the numerous theories that have been held regarding electricity, the nomenclature has been very confusing and very misleading. Growing out of the old idea that electricity was a fluid, the term current has fastened itself upon the science, as an expression of the electro-dynamic condition of a conductor. Notwithstanding we know so little about electricity, there are but few men in these times who do not believe that it is only a *condition* that matter assumes under certain circumstances, and *not* matter itself. Just what this condition is, we find it hard to explain. There is strong evidence, however, that electricity, like heat, is molecular motion. Heat motion, as expressed by the movement of the molecules of matter, is sluggish when compared with electric molecular motion. The difference between the two motions may simply be in rate, or it may be in form, or in both; most likely the latter. With heat it would seem that the molecule has an orbital or circular motion and that their planes of motion do not coincide as, for instance, in polarized light, are but like the unpolarized rays where the planes of vibration radiate in all directions. This would seem to be the case from the fact that a heated body *expands* in all directions. An electrified conductor does not perceptibly expand unless there is a conversion into heat. The molecular movement is probably in the same plane, and the energy is propagated by the impact of one atom or molecule against another successively.

Such a motion would be more rapidly transmitted through a conductor than the one described as heat motion. Electricity would seem to represent the working energy expended in changing from a high to a low potential. I do not mean that every such change would be so represented, for if we should elevate a weight of a given size and density from the ground, the measure of its ability to do work in falling, other things being equal, would be determined by its height. The energy expended in falling might be converted into mechanical motion and do work, such as the turning of wheels, or it might be converted into electricity or heat. If left free to fall through the air, after the weight had reached the earth, the energy expended in falling would exist in the form of heat; some caused by friction against the air, but mostly by the impact of the weight against the earth, which would cause a molecular motion in the weight and the earth, the mechanical equivalent of which would be a force sufficient to elevate the weight to the same height from which it fell. One important condition for the production of dynamic electricity is a circuit composed of some known conductor of this energy. If we place a piece of zinc and a piece of copper in a room of the same temperature, the zinc will absorb more heat than the copper. As a consequence the molecular motion of the zinc is greater than that of the copper. The amount of molecular motion in a metal is a measure of its potential; so that the potential of the zinc is greater than that of the copper. Now, energy in action is always from a higher to a lower plane: if the energy is potential, or at rest, the *tendency* is from a higher to a lower. If we arrange these two metals in a circuit in the form of a galvanic battery, the higher potential will descend to the lower in the form of electricity, and its passage will do work. The higher potential is not released until the acid dissolves the zinc. As the dissolution progresses, the potential energy becomes kinetic and falls to the lower plane, and in its descent the energy takes the form of electricity. It is a well known fact that if we heat one part of a metal ring a current of electricity is set up, but as soon as the ring becomes equally heated throughout, the current ceases. At first the potentials of the different parts of the ring were unequal, and a flow of energy is set up as a consequence of the process of equalization. According to the above, there would seem to be a close relation between heat and electricity, and that under certain circumstances it acts as an equalizer of heat.

We have already shown the close relation between heat and light. Now let us see what relation electricity bears to both, and what relation they all bear to each other. I have shown that the unequal distribution of heat produces electricity. Every schoolboy knows that electricity produces *heat* and *light*. As an instance we cite you to the electric light that may be seen any evening.

The convertibility of these expressions of force, the one into the other, is perhaps the strongest proof of their identity of origin.

As we said at the outset, the *particular* expression depends upon the quality and relations of the material upon which force acts. Here is one of Crooks's tubes. It consists of a series of three glass bulbs exhausted to the millionth of an atmosphere. They are made of three different kinds of glass. In ordinary light these look alike, but there is a difference of texture. One is uranium, one English, and one German glass. There are only a few air molecules left in the bulbs. So few, that one may be projected the whole length of the tube without striking its neighbor. When I turn on a current of electricity, the atoms are violently thrown against the sides of the tube. The result of this violent impact is heat and light. The tube becomes hot and luminous, showing a very high degree of molecular excitement. You all see that the light in the different bulbs is differently colored. Now the same force is acting on all. The different expression is not because the force is different, but because it acts on material having a structural difference. Here is also an instance of the conversion of electricity into heat and light. [*Iceland spar.*] I will now show you an instance of the conversion of heat into electricity. I have here what is called a thermo-electric pile. It consists of alternate layers of antimony and bismuth bars joined at their extremities so as to make a continuous circuit terminating in these binding screws.

If these binding screws are connected by a conductor of electricity, and the temperature of the face of the pile is raised or lowered in the least, a current of electricity will flow through the circuit. If raised in temperature, it will be in one direction, if lowered, in the opposite. Now, if I include in this circuit a galvanometer, the deflection of its index needle will show the presence of a current, and also its correlative heat or cold. I have arranged it so that an image of the needle will be thrown on the screen. Now, I want to prove what I told you about the falling weight—that a stoppage of its mechanical motion resulted in heat or molecular energy.

I have here a strip of metal, and as it has been lying some time it is probably of the same temperature as the thermal pile, and will produce little or no effect upon the needle. I will give it a few blows with a hammer and again apply it to the face of the pile, and you at once see a decided deflection of the needle.

Let us now trace the transmutations of energy so far as we have gone, starting with the blow of the hammer. Here mechanical energy has been changed into molecular in the form of heat. A part of this heat is found in the strip of metal. I applied it to the pile and converted a portion of it into electrical energy which expends itself partly in producing visible mechanical energy by moving the needle, which in turn is transformed into heat. Here are four transmutations; from mechanical to heat energy, from heat to electrical energy, from electrical to mechanical again, and finally from mechanical into heat. I have here a piece of copper wire, and as in the case of the strip of metal, it is of the same temperature as the room and produces no effect on the pile. I now bend it a few times vigorously, thus causing a friction between the particles, which produces a molecular excitement. This is shown, as before, by the deflection of the needle. All the transmutations are the same as before. I have only employed a different form of mechanical energy.

We have seen that electricity has produced heat and light, and that heat will produce light and electricity. It now remains to see what light will do in the way of producing electricity and heat.

It is more difficult to show the effect of light, from its very close relation to heat. It is clearly shown that light has powerful chemical properties independent of heat. Photography is an instance of its chemical power. It is also shown that light, when absorbed, becomes heat. And whatever becomes heat will become electricity.

If I should direct the sun's rays upon one end of this thermo-electric pile, while the other was covered, electricity would be generated. This result could be accounted for by the heat that accompanies the luminous rays. On the other hand, it is difficult to prove that every luminous ray is not in some degree a heat ray. Also, if all the luminous rays were shut off and only the dark rays were absorbed by the pile, the deflection of the needle would show a less amount of heat absorbed. If we spread a black and a white cloth upon the snow, it will melt under the black cloth much faster than under the white, because all the sun's rays are absorbed by the former and converted into heat, while from the latter they are reflected.

It seems to me that the question before us to-night is fully answered in the operation of the electric light. It *might* be put in another way, and read: Have these phenomena—heat, light, and electricity—a common origin? To illustrate, let us take the case of a waterfall. A waterfall is the result of what is called the force of gravity. The water, by the power of the sun's rays, has been placed in a position where the force of gravity can act upon it. The result is motion or moving energy.

If we place a water wheel in the proper relation to the fall, the wheel will turn and do work. Now we can, by the movement of this wheel, put in operation a dynamo-electric machine which will generate a powerful electric current, which in turn may be carried to an electric lamp, where what was electricity takes on the form of heat and light. If we stop the wheel, the current ceases and the heat and light cease. All three exhibitions of energy came from the same source, namely, the waterfall. But this is not all the wheel will do. We could cause it to drive machinery that would produce every conceivable mechanical motion—circular, irregular, intermittent, reciprocal, pendulous, etc.

If the waterfall and wheel were large enough, we could at the same time light a city, drive a train of cars, and send ten thousand messages to all parts of the land, and have all these operations dependent upon the continuous turning of one wheel; more than this, while all these operations were going on, we could strike the hours of the day in every clock tower in the land; not only could we strike the hours, but we could regulate the pendulums of the clocks. At the same time we could fire cannon, either simultaneously or successively, in every *city* of the land. We could warn every household of the approach of a burglar, and not only give *warning*, but on the instant of his entrance turn up the lights and illuminate the house. I might go on for hours reciting operations that could be carried on all at the same time and in different parts of the country, and all of them made dependent upon the continuous turning of one and the same wheel. This, however, is only the faintest conception of what is actually going on. The sun is the great source of all the operations of our solar system. It is the great master wheel that gives activity to all the machinery of *our* planet and many others like it.

All motion of material things, animate or inanimate, whether in the earth, on the earth, or above the earth, is the offspring of the sun's silent energy. He is alike father to the soft zephyr that fans gratefully the cheek, and the cold blast of winter which carries suffering, death, and destruction in its course. The same genial sunbeam that makes all nature smile on a summer's morning, that gives life and joy to all animated things, that causes the leaf to grow and the flower to bud and bloom, that clothes all nature with beauty and loveliness; the same merry sunbeam, later in the day, brings the angry cloud, the pouring rain, the blinding flash of lightning, the terrific peal of thunder, and the still more dreadful tornado. By the magic of his spots the sun casts an undefinable shadow across our globe, thus causing a sudden change of potential in this great thermal battery, the earth, and an electric storm follows which paralyzes the telegraph service, and for one day at least he is king of Wall Street. And at night, as if to show his contempt for man's puny inventions, he hangs an electric lamp in the northern sky, and another in the southern, and they two light the whole world. Such is an outline history of the frolics of the sunbeam for one day. The intermediary work done in connection with one day's events, growing out of the sun's radiant energy, could not be recited in a lifetime.

Finally, it is impossible to study closely the properties of matter and the various phenomena exhibited in its relation to energy, without coming to the conclusions that all energy, in whatever form it may appear to our senses, is the offspring of one common parent.—*The Weekly Magazine.*

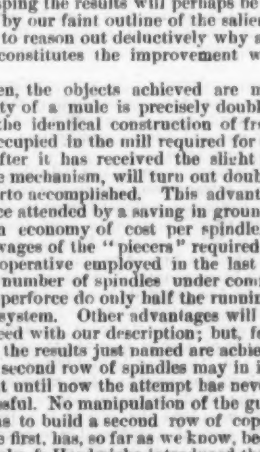
DUPLEX MULE SPINDLE.

As we have repeatedly stated in the leading columns of this journal, recent years of trade depression have been attended by at least one good result, viz., that of the increased application of science and mechanical improvement in the manufacturing districts of England. Besides being subject for congratulation as constituting a healthy development of the nation's mental resources, it speaks well for the pluck and inventiveness of our manufacturers, who intend not to be beaten in the race of competition with other countries, if they can help it. In comparing our present machinery with that in use some twenty years ago, and bearing in mind the almost fabulous increase of work in our patent offices, we feel confident that if this country fails to hold her position among the manufacturing nations of the earth, it will not be from lack of either inventiveness or effort. It is almost a pity that a nation should be so handicapped by adverse tariffs that it has to fall back upon the resources of invention in order to meet a competition which is unfair; but such is, nevertheless, the fact, and it is only by the utmost application of science, and the most rigid consideration for economy in methods of production, that our manufacturers are enabled to achieve even a moderate degree of success.

While noticing these particular phases of the woolen and worsted industries, we are led to give prominence to those inventions which really seem to attain the ends above referred to. A desire to keep our readers *au courant* with everything that pertains to the textile industries induced us to visit the works of Messrs. Cooke, Sons & Co., at Liversedge, with a view of inspecting the "duplex" system of mule-spining hereafter described. The importance of this invention may be best understood by describing objectively the process and mechanism of the improved system. The reader grasping the results will perhaps be enabled for himself, aided by our faint outline of the salient features in the apparatus, to reason out deductively why and wherefore the invention constitutes the improvement we represent it to form.

First, then, the objects achieved are mainly as follows: The capacity of a mule is precisely doubled, which means that with the identical construction of framework, length, or space occupied in the mill required for the old mule, the machine, after it has received the slight addition of some very simple mechanism, will turn out double the amount of work hitherto accomplished. This advantage is, it will be seen, at once attended by a saving in ground space, in power required, in economy of cost per spindle, and also in the labor and wages of the "piecers" required to keep the ends up. The operative employed in the last vocation, having double the number of spindles under command in a given area, must perforce do only half the running about required by the old system. Other advantages will become apparent as we proceed with our description; but, for the present, let us see how the results just named are achieved. The application of a second row of spindles may in itself seem simple enough, but until now the attempt has never proved practically successful. No manipulation of the guide wire, in such a manner as to build a second row of cops, in all respects equal to the first, has, so far as we know, been devised before Messrs. Cooke & Hardwicke introduced their improvement. It was necessary that one row of spindles should be shorter than the other, and compensation for this divergence must be found in the adoption of such mechanism in the uprights carrying the faller wires as would lead to this result. These uprights being swelled in or near the middle out of perpendicular, and also aided by a cam or swell-motion, are enabled to effect the necessary compensation, and to successfully perform the operation of cop-building.

The following diagram represents the spindles and ends, as they appear looking down upon the mule from its front,



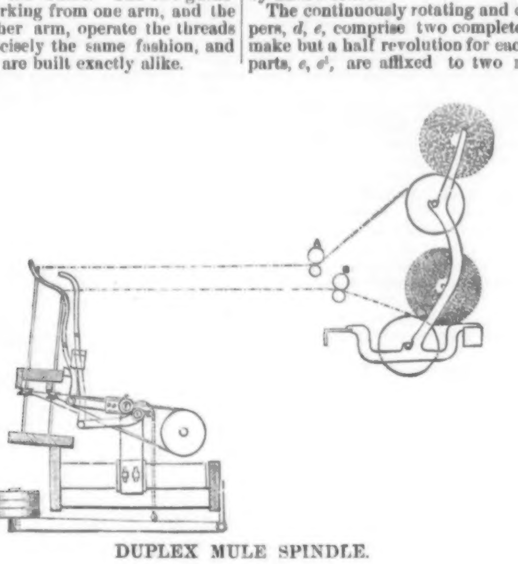
the round black dots showing the two rows of spindles, and the dotted lines representing the ends.

It is here necessary to carry the eye down to the engraving beneath, which represents a section of the apparatus.

The front row of spindles shown at the extreme left of the above cut are, it will be seen, longer than the second row immediately behind them. Herein lies a most important point—one which has, undoubtedly, contributed to the success of the invention. It being a mechanical impossibility to effect the cop building with both rows of the same length, we lay stress upon the feature just referred to, as constituting something entirely novel, and introducing a fresh mechanical principle into the working of the faller, or guide-wires. Those who have tried the experiment know that two rows of spindles of the same length would be impracticable, as the two sets could not be made to work together.

Having demonstrated the "duplex" system, let us see what are the subsidiary motions required to carry it out.

Looking at the ends as they are coming from A and B, it will be seen that each row has its own set of rollers, the distance and situation of rollers to spindles being relatively the same. In place of the usual "sickles," carrying the guide-wires, and working from the front of the mule, the following plan is adopted: The faller-rods are placed behind the spindles, and out of sight. Small arms or levers attached to the rods marked E and F give motion to the upright guides previously referred to, and which will be readily recognized in the cut by their bent or crooked appearance. The cam lying between the second spindle and the first upright guide (*vide* illustration) operates as a gradual chuck, in order to obtain the necessary radius which the thread requires as it is being wound on the cop. The mechanism, while being in part similar—so far as the arms and faller-rods are concerned—to the old method, has, it will be seen, important features of divergence besides that of being shifted to a different part of the frame. The two guide-wires, on one upright and working from one arm, and the two building wires on the other arm, operate the threads on each row of spindles in precisely the same fashion, and therefore the cops on each row are built exactly alike.



DUPLEX MULE SPINDLE.

The pitch of the spindles is $3\frac{1}{4}$ in., and the space between the ends is $1\frac{3}{4}$ in. This mule is single, and contains 270 spindles, but the invention can be applied to mules of any usual length.

It is intended to apply the invention to mules of much finer pitch, going to the extreme limit of practicability consistent with the threads having free play, without risk of fouling each other. By allowing the usual row 25 per cent. more spindle space, the "duplex" method might be utilized in order to fill the extra space, and 75 per cent., instead of 100 per cent., would then represent the increased production. The duplex system may also be applied to twisting mules.

We have previously referred to the saving effected in the labor of the "piecer," and a corresponding advantage is obtained in cost of overlooking, the rate of wages per spindle being considerably lessened by the new system, and better work is at the same time insured.

Not the least important item in the "duplex" arrangement is that it meets a want long felt in the woolen industries, viz., that of having a sufficient reserve of spinning power when on fine yarns, in order to keep pace with the carding operation, which, it will be known, is generally ahead of the mule when on fine yarns, and is behind it in production when on thick counts. To regulate the sum of material produced to that actually required is much easier in the case of the "duplex" than in that of the old system, especially as we are able in the "duplex" system to throw one set of spindles out of gear in case the "mule" production should exceed the "carding" production. The extra row may be placed and displaced in a few minutes. A careful scrutiny of all the points in the invention induces us to coincide with the opinion that the system is a pronounced success; and, as the cost of adopting it is very trifling, the improvement would seem to have before it a long and extensive career of usefulness in the spinning trades.—*Textile World.*

TRUXLER'S NEW CARDING MACHINE.

FOR a few years past, considerable work has been done in the textile industry with a view to devising new machines for carding and hackling that should be more powerful and economical, and capable of carding fibers that could not be prepared on former machines. Several new machines of this kind were exhibited at the Universal Exhibition of 1878, and contributed not a little to urge mechanics of different countries on to new researches.

But, of all the inventions brought out since that period, very few may be said to be capable of rendering genuine services to the textile industry, and to constitute a practical progress.

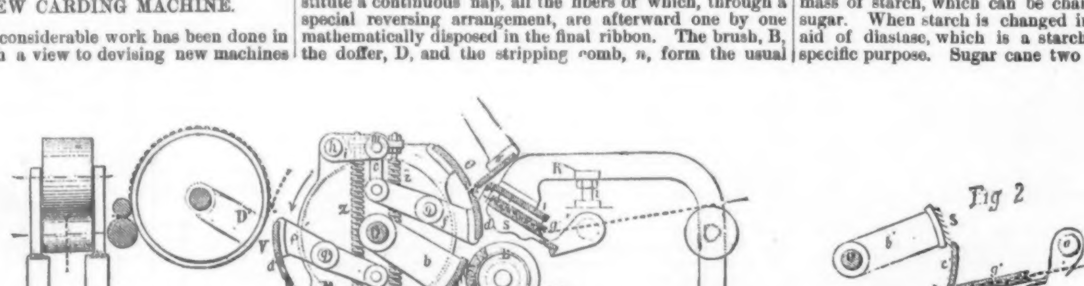
Of those that have given the most satisfactory results, we may mention the remarkable machine devised by Mr. H. Truxler for carding wool, and which is represented herewith in section in Figs. 1 and 2.

In this machine the oscillating feeder consists of a double lattice plate, *g*, capable of moving backward and forward along its supports, *s*, which oscillate around the center, *o*. Above this is a comb, *r*, with rows of needles that enter the spaces of the double lattice, *g*, when the latter is raised to the extreme height of its travel. The arms, R, which carry this comb, rest on the regulating screw, *v*, and are capable, when necessary, of oscillating around the center, o^1, in order to lift the comb when the machine is to be cleaned. The tresses of wool traverse the interval between the lattices, *g*, by hard friction.

The continuously rotating and double acting drawing nippers, *d*, *e*, comprise two complete and like devices which make but a half revolution for each complete operation. The parts, *e*, e^1, are affixed to two revolving disks, P. The parts, *d*, d^1, are affixed to levers, *f*, f^1, pivoting around the points, *q*, q^1, and opening or closing upon the parts, *e*, e^1, according to the undulations of the two fixed curves, M, that act upon the pivots, *m*, m^1, carried along in the rotary motion of the disks, P. The screws, *z*, z^1, act at the same moment upon these pivots, *m*, m^1, and the opening of one of the nippers, *d*, e^1, thus secures and strengthens pressure upon the opposite nippers, *d*, *e*, which have closed at the same time. The disks, P, are loose upon the shaft, O, and receive their rotary motion independently of it; the shaft, for its part, making an oscillation only to bring about the necessary motion of the carding segment, S.

The operation begins with the position shown in Fig. 2, one of the nippers, *de* or de^1, coming up open in front of the lowered lattice, *g*. This latter slides forward on its supports, *s*, in order to hasten the introduction of the tress, upon which the nippers soon close, so as to leave about 18 or 20 millimeters of the fore end to lap over internally. The two parts then rise in contact with one another; the lattice gradually recoils upon its guide; and the carding segment, S, meanwhile descends and cards the extremity of the sliver. The two parts, which are always in concordance, thus pass the line of the centers, Oo, and then begin to separate. The nap held in the nippers is necessarily drawn through and out of the lattice to an extent which represents the quantity fed at the next operation. At this moment the nippers begin to open and allow the nap to free itself until but the extreme point of the carded end is engaged, and upon this latter the nippers again close. The lattice and nap then fall against the needles of the comb, *r*, and against those of the tail comb, *x*, and stop thus in the position shown in Fig. 1, while the nippers, revolving, extract the carded sliver and carry it along. The carded slivers are delivered to a doffer, D^1, through the opening of the nippers upon coming in contact therewith. Each sliver, in its turn, fixes itself thereto by its front extremity, and the piece, V, rising quickly, extends and spreads out regularly the tail end of the sliver, however long it may be. The slivers thus superposed constitute a continuous nap, all the fibers of which, through a special reversing arrangement, are afterward one by one mathematically disposed in the final ribbon. The brush, B, the doffer, D, and the stripping comb, *n*, form the usual cleaning arrangement for removing the residues of the operation from the carding segment, S.

The extent to which the sliver may be drawn out on this machine—embracing nearly a third of a circumference of 120 to 150 centimeters—renders it applicable for varied lengths of fibers, from the shortest to the longest wools, to the fibers of China grass, flax, etc.—*Le Génie Civil.*



IMPROVED CARDING MACHINE.

HOW NATURE SWEETENS OUR FRUITS.

DR. JAMES R. NICHOLS delivered an address on "The Sweet Principle of Fruits and Plants." Substances characterized by sweetness are assumed to contain an organic product called sugar. This is a very remarkable substance, and its investigation opens to view surprises and paradoxes not afforded by any other agent in nature. It is highly complex in its organization, having a high atomic constitution, and yet it is the simplest of all compounds when considered in regard to the nature of the elements of which it is composed. In studying the sweet principle of plants, we soon discover that they possess the capability of elaborating more than one variety of sugar, and that there is a curious blending of several forms in the ripened fruits which come upon our tables. We discover also that each plant has the power of manufacturing a special variety, or a combination of varieties, and that this law of their constitution cannot be changed by man. In beet roots, in the stems and trunk of the sugar-maple tree, the sycamore, the palm, in sugar-canes, in the sorghum plant, in the stalk of maize, in grasses, we have one kind of sugar, called *sucrose*, which is the sweetest variety; in grapes we have another distinct variety, called *dextrose* or *glucose*; in apples and other fruits we have still another called *fructose or levulose*. In melons we have a sweet which is nearly pure sucrose, or cane sugar. We learn from this examination not only that sugars differ widely, but that, for wise and doubtless beneficent reasons, the Supreme Intelligence has not permitted all fruits and plants to be sweetened alike. In that vegetable monstrosity called a beet, which is hidden from the clear sunlight and the air during the whole period of its growth, there are found juices which hold the most noble and valued form of sugar known to man. The crimson tissues of this root contain the snow-white sugar which graces the tables of the kings and princes of Continental Europe, and millions of pounds find their way into commerce, always commanding the highest prices. The humble, earthy beet can hold up its head with pride when its sweetness is contrasted with that of the petted grape, which occupies the foremost place among our delicious fruits. The grape is sweetened with glucose, an ignoble form of sugar, which the chemist can make in the laboratory, where its production does not require the employment of costly or rare materials. Even if it lessens our respect for the tempting fruit of the vine, the truth must be told. The chemist can make the sweet juices of the grape from old cotton rags and old newspapers; and if this statement does not indicate a sufficiently low origin, we have only to state that it can be made from common sawdust as well. But human art has not yet been able to number among its triumphs the production of the sugar of the beet, the maple, or the cane. It is probable that the peculiar, delicate flavor of the grape could not be secured by any adjustment of quantity of sucrose or cane sugar, or by any mixtures. It requires glucose, pure and simple, to act in conjunction with the delicate acids, that we may have this fruit in its highest perfection. The watermelon would not be the fruit it is if it had not the capability of manufacturing cane sugar in large quantities; neither would the apple, the peach, the cherry, the strawberry, or the pear be what they are if the plants and trees upon which they grow had not the power of bringing into play a subtile chemistry, by which is produced a mixture of distinct forms of sweets which no art of man can imitate.

But Nature does not, in the bestowal of her fruits, spontaneously or of her own free will sweeten them for us so acceptably. Not one of the fruits in their wild or native state holds any considerable quantity of sugar of any kind—not enough to make them acceptable to the taste or to fit them to serve as foods. It is only by skillful cultivation, by hybridizing, by budding and grafting, that we have secured the sweet principle in fruits. We have, as it were, educated the dumb chemists in the vegetable cell, and fitted them for the work which Nature made them competent to perform under man's guidance. The beet, for example, under ordinary care will afford from four to six per cent. of sugar, but by scientific and generous culture the percentage can be nearly or quite doubled. The speaker has succeeded in increasing the sweet principle in apples, grapes, and peaches by cultivation and fertilization, and this when it was originally present in normal quantity. In increasing the sugar, we also increase every other desirable quality, for one principle can not be forced into prominence without being accompanied by all the others.

Dr. Nichols here explained, with the aid of diagrams, the chemical constitution of sugar, starch, and cellulose, all of which are classed as carbohydrates. Cane sugar is a combination of water with carbon—absolutely pure water with the elements of a diamond. Starch can be transformed into glucose by the addition of one molecule of water, but the glucose cannot be transformed into sucrose. A potato is but a mass of starch, which can be changed almost entirely into sugar. When starch is changed into sugar, it requires the aid of diastase, which is a starch solvent, provided for a specific purpose. Sugar cane two weeks before it is ripe contains no starch sugar; after it is ripe it contains no starch. Sugar is not an exhaustive product, the refuse from the manufacture of beet sugar returns all inorganic matters to the soil.

But while it is possible to increase the saccharine principle, and also to modify the hydrated malic acid constituent in fruits, it is entirely beyond our power to change the fixed

nature of vines or trees by any methods of cultivation or fertilization. There is nothing more wonderful in nature than the persistency with which vegetable structures adhere to their original bent or design. We all know that two trees growing side by side, from the same soil, breathing the same air, and precisely alike in external and internal substance, will produce fruit totally dissimilar in chemical constituents and physical appearance. If a young sour-apple tree is cut off low in its trunk, and scions of another kind are inserted, it is changed only above the point where they are placed. The chemical reactions below continue true to the original instinct, and if fruit cames from a sprout it is charged with the acid juices of the parent tree. We have thus the bewildering fact brought before us that the sap circulating through one portion of a tree culminates in the production of excess of acid in the fruit, while in another there is found an excess of sugar. It is not unusual to observe a newly set scion bud, blossom, and bear fruit the first year. The fruit may weigh ten times as much as the frail scion which held it up and supplied the nutriment necessary for its growth. But the little twig, transplanted to an alien limb, will set up a laboratory of its own, and from the strange juices brought to it will manufacture fruit totally dissimilar to its companion fruits, growing in close proximity. An example of this nature was afforded in the orchard of the speaker, when, from a scion having a surface for cell action of only nine square inches, a sweet apple was grown weighing seven ounces, and affording from its juices ninety-three grains of fruit sugar. Still more wonderful examples of fruit chemistry are shown in apples, which in their own structure exhibit sectional differences of composition, one-half or one-quarter being saccharine, and the other portions being extremely acid, and having the sectional lines distinctly drawn.

Dr. Nichols next gave some results of analysis of apples, with a view to ascertain their great value as food, from which it appears that in a bushel of ripe Hubbardston Nonsuches there is about six pounds of soluble nutritive material, in Tolman's Sweets about seven pounds, and in Baldwins about five pounds; and this material will vary to a considerable extent in value. These results agree with practical experience in feeding apples to animals. When fed in connection with meal, they serve to give zest to the appetite, and to keep the animals in health. If cooked, their value is much increased.—*Boston Trans.*

PRUSSIC ACID IN THE JUICE OF CASSAVA ROOT.

It has lately been found by Mr. E. Francis that the prussic acid, which for some time has been recognized as the poisonous element of bitter cassava root (*Manihot utilissima*), is also present in the juice of sweet cassava root in nearly as large proportions. The results of his analyses are tabulated as follows:

Sweet Cassava (15 samples).

	Per cent. of Prussic Acid.	Grains of Prussic Acid per lb.
Average	0·0168	1·175
Highest	0·0238	1·666
Lowest	0·0113	1·791

Bitter Cassava (10 samples).

	Per cent. of Prussic Acid.	Grains of Prussic Acid per lb.
Average	0·0275	1·927
Highest	0·0422	3·094
Lowest	0·0132	0·924

The sweet cavassa was obtained from Trinidad. Nine of the fifteen samples contained in one pound of the root, or one-half pint of the juice, enough of the acid to kill an adult.

It must be remembered, however, that in the process of making tapioca (for which the root is largely used) the acid, being volatile, is completely driven off from the starchy matter.

SYNTHESIS OF URIC ACID.

The synthetic production of uric acid has been accompished by Horbaczewski. Pure, finely pulverized glycocol was mixed with ten times its weight of pure urea and heated quickly to 200° or 230° in a metallic bath, being kept there until the colorless liquid became a yellow, turbid and pasty. After cooling, the mass was dissolved in dilute KOH, saturated with NH_4Cl and precipitated with a mixture of ammonia-silver solution and magnesia mixture. The precipitate after washing was decomposed with potassium sulphide. The filtrate was saturated with HCl, and concentrated. The crude product by solution in alkali and reprecipitation was purified. A yellowish crystalline powder resulted which possessed all the properties of uric acid. Under the microscope the crystals were plates or rhombic chrystals. They reduced copper solution on warming and silver solution in the cold. They dissolved in nitric acid, and left on evaporation an onion-red layer becoming purple red with ammonia and violet with potash. They are not soluble in water, alcohol, ether, or acids, but soluble in alkalies, and gave the right formula on analysis.—*Ber. Berl. Chem. Ges.*

BENZOIC AND BORIC ACIDS IN MILK.

By Dr. E. Meiss.

For benzoic acid 250 to 500 c. c. of milk are rendered alkaline by means of a few drops of lime or baryta water, evaporated down to one-fourth, stirred up to a paste with gypsum, and dried on the water-bath. Sand or pumice may be used instead of gypsum. The dry mass is finely powdered, moistened with dilute sulphuric acid, and three or four times shaken up with double its volume of cold alcohol at 50 per cent. The alcoholic extracts, which, in addition to benzoic acid, contain lactose and inorganic salts, are united, neutralized with baryta water, and concentrated to a small bulk. This residue is again acidulated with dilute sulphuric acid, and finally shaken up with small quantities of ether. The ethereal extract on evaporation leaves benzoic acid in a state of almost absolute purity. For the quantitative determination this residue is dried in the desiccator, weighed, the benzoic acid is expelled by sublimation, and the residue is weighed agaain, the loss being benzoic acid. Sublimation is best effected in the water-bath, the capsule being covered with a watch-glass. As soon as the benzoic acid begins to sublime, the space beneath this glass appears full of minute spangles of benzoic acid, and is very characteristic. As soon as the larger portion of the benzoic acid is deposited in the covering glass it is removed, and the contents used for qualitative reactions. The lower capsule is heated uncovered till all the benzoic acid has escaped. The test with neutral ferric chloride succeeds best with the benzoic acid dissolved in water and mixed with a drop of sodium acetate. Boric acid is not capable of quantitative determination, except present in such quantities that its weight may be deduced from the increased percentage of the ash. The flame-reaction is untrustworthy, as the ash of pure milk gives a flame bordered with green. The following method is recommended: 100 c. c. milk are rendered alkaline with lime water, evaporated down, and incinerated. The ash is dissolved in a minimum of strong hydrochloric acid, filtered from the carbon, and evaporated to dryness. The residue is moistened with a little dilute hydrochloric acid, the crystalline paste is moistened with tincture of turmeric, and dried on the water-bath. In presence of the smallest trace of boric acid the dried residue is of a distinct vermilion, or cherry red. In this manner 0·001 to 0·002 per cent. in the milk can be distinctly recognized. Strong hydrochloric acid gives also a cherry red color with turmeric, which, however, disappears on the addition of water, and on drying turns brown. The boric color only appears on drying, and is not removed by water except boiling or in excess.

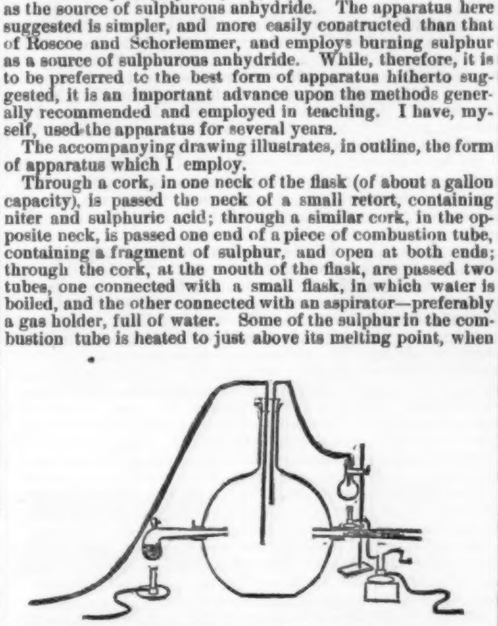
APPARATUS FOR ILLUSTRATING THE MANUFACTURE OF SULPHURIC ACID.

By Alfred Senier.

The forms of apparatus described in chemical works for the purpose of illustrating the sulphuric acid manufacture experimentally, very generally involve the logical error of taking the full quantity of sulphuric acid to begin with. This is to be avoided for educational reasons. There are, however, some exceptions to this general rule, and notably the apparatus recommended by Roscoe and Schorlemmer,* in which they employ sulphur, burned in a current of air, as the source of sulphurous anhydride. The apparatus here suggested is simpler, and more easily constructed than that of Roscoe and Schorlemmer, and employs burning sulphur as a source of sulphurous anhydride. While, therefore, it is to be preferred to the best form of apparatus hitherto suggested, it is an important advance upon the methods generally recommended and employed in teaching. I have, myself, used the apparatus for several years.

The accompanying drawing illustrates, in outline, the form of apparatus which I employ.

Through a cork, in one neck of the flask (of about a gallon capacity), is passed the neck of a small retort, containing niter and sulphuric acid; through a similar cork, in the opposite neck, is passed one end of a piece of combustion tube, containing a fragment of sulphur, and open at both ends; through the cork, at the mouth of the flask, are passed two tubes, one connected with a small flask, in which water is boiled, and the other connected with an aspirator—preferably a gas holder, full of water. Some of the sulphur in the combustion tube is heated to just above its melting point, when



EXPERIMENTAL SULPHURIC ACID APPARATUS.

it ignites, on a gentle current of air being caused to flow over the sulphur, into the flask, by means of the aspirator. Once started, the sulphur continues to burn, by the heat of its own combustion, so long as the current of air is maintained. If it is wanted to introduce air, it can be done easily, without an extra tube, by stopping the aspirator a minute; when the burning sulphur is extinguished, and cooling below its ignition point, a flow of air passes over it, through the combustion tube, when the aspirator is again turned on. The sulphur can again be raised to the ignition point by momentary application of the Bunsen flame. In other respects, the mode of working is sufficiently obvious.—*Pharm. Jour. and Trans.*—*New Remedies.*

PROPERTIES OF NITRO-GLYCERINE.

It has a sweet, aromatic, pungent taste, and possesses the very peculiar property of causing an extremely violent headache when placed in a small quantity upon the tongue, or any other portion of the skin, particularly the wrist. It has long been employed by homœopathic practitioners as a remedy in certain kinds of headaches. In those who work much with it, the tendency to headache is generally overcome, though not always. It freezes at about 40° Fahr., becoming a white half-crystallized mass, which must be melted by the application of water at a temperature of 100° Fahr. If perfectly pure—that is, if the washing has been so complete as to remove all traces of the acid—it can be kept for an indefinite period of time; and, while many cases of spontaneous combustion have occurred in impure specimens, there has never been known such an instance, where the proper care has been given to all the details of the manufacture.

When pure, nitro-glycerine is not very sensitive to friction, or even to moderate percussion; if a small quantity be placed on an anvil and struck with a hammer, that portion which is touched explodes sharply, but so quickly as to drive away the other particles; if, however, it were even slightly confined, so that none could escape, it would all explode or detonate. It must be fired by a fuse containing fulminate of mercury (the compound used in percussion caps), not being either readily or certainly fired by gunpowder, the shock of the latter not being sufficiently quick or sharp to detonate the nitro-glycerine. It is highly probable that in this case, as in that of other high explosives, the vibrations set up by the fulminate (which is not stronger than gunpowder) are of just such a character to find an answering chord, so to speak, in the explosive, so that the desired effect is produced. This would seem to be a correct theory, for it is not always the most powerful explosive which most readily causes the explosion of another body. For instance, although nitro-glycerine is much more powerful than fulminate of mercury, yet seventy grains of it will not explode gun-cotton, while fifteen grains of the weaker fulminate will readily do so. The fuse generally used, then, for firing nitro-glycerine, is composed of from fifteen to twenty-five grains of fulminate, and this quantity is sufficient to detonate a large mass as well as a small one.

If flame be applied to nitro-glycerine it will not explode, but burn with comparative sluggishness. When frozen it is very difficult and uncertain of firing. If the material be perfectly pure it forms, upon detonation, a volume of gases nearly thirteen hundred times as great as that of the original liquid; these gases are also further expanded, by the heat developed, to a theoretical (though not practical) volume ten thousand times as great as that of the charge. Practically speaking, the forces exerted by gunpowder and nitro-glycerine are in the same proportion of one to eight.—*From "Explosions and Explosives," by Allen D. Brown, in Popular Science Monthly.*

* Treatise of Chemistry, i., 322.

AMORPHOUS PARAFFIN.

Mr. Charles Tappan, chemist, claiming to be the discoverer and patentee of the valuable product of petroleum known commercially as cosmoline, vaseline, and petrolina, recently published a paper explaining the nature of the substance known chemically as amorphous paraffin, the method of its manufacture, also some of its uses. We summarize as follows:

Amorphous paraffin is defined as paraffin not in condition, its true condition being a crystalline form. The process of manufacture is thus described:

It requires a rich, fatty, gelatinous oil, mostly obtained from Bradford County, Pa., to be either distilled in a vacuum, or evaporated in open pans over a sand bath at a low heat driving over the light hydrocarbons or evaporating them off, leaving in the still a rich, fatty, black oil, sweet in odor. This oil is then placed in filters of 20 to 25 feet in height filled with animal charcoal, through which it is filtered. The various grades in color are entirely due to the different points in filtration; the first oil coming through the filter being nearly milk white and having the best odor. The percentage of this quality is very small. Soon it is of a golden hue, which grows darker until the bone has lost its action—the oil passing through without change as to color.

This product is inert, or should be, and as a base for ointments and as a lubricant it is most excellent; but its medicinal qualities are very slight. It has two objections as a vehicle for ointments; first, when heavy medicinal ingredients are used, as red precipitate or mercury, they are liable to precipitate in a warm temperature; second, being insoluble, it coats or varnishes medical ingredients incorporated in the ointments with an insoluble varnish, so that when the ointment is applied but a partial effect is received. This amorphous product cannot be made from natural oils, burning oils, tar, etc., because natural oils differ in structure from distilled oils. For making a uniform, inodorous, and unscorched product, the vacuum distillation is necessary. Distillation in a vacuum has the peculiar effect of bursting or breaking the oil globules, while the destructive distillation in common use has no such effect. Boiling at a low temperature and sucking of the light vapors with the pump, gives a very pure and sweet residuum, especially adapted for the manufacture of amorphous paraffin.

It is a mistake to suppose that amorphous paraffin can be rubbed into the body. The heat of the body in addition to the artificial heat caused by friction in rubbing causes the oil to disappear in gas, not a trace going into the system. Nor is it of any benefit taken internally other than as a lubricant. By several close and careful tests three ounces taken internally passed through the body intact, recovering the full three ounces, the gastric juices not having the least influence on it; though it is beneficial as an emollient to soothe and give relief as a lubricant. It has advantages over sweet oil, lard, and similar substances as a dressing for burns, scalds, etc., one of which is that it will not decompose. It is often the case that poison generated by the decomposition of dressings is more difficult to cure than the wound itself, and this product is now recognized in the new edition of the Pharmacopœia.

The committee in charge of the revision of the Pharmacopœia have made a thorough and exhaustive examination of the subject during the past two years, investigating all the great varieties of paraffin thought to be suitable for a base. One practical and well-known druggist made a visit to the oil regions for this particular purpose. For a base containing some of the properties of the amorphous paraffin, he offered the well known product of red wax as an amorphous product. In this he was mistaken. It is not in an amorphous condition, neither can it be refined for practical use, except at a cost which would make it prohibitory. No refiner has ever been able to deodorize this peculiar substance, red wax, which appears to have collected the essence of the pungent odors so characteristic of petroleum. Red wax, when melted in a still, at once assumes the true form of paraffin. The melting point of the new base has been a question of much discussion in the different medical and pharmaceutical societies, the doctors desiring two melting points, while druggists wish for only one. All this difference of opinion can be overcome by a petroleum that has a high melting-point, and at the same time the peculiar quality of being capable of rubbing down, or as many suppose, into the body. This is what some might call a low melting point. One writer suggests the use of B. S. oil: but this oil is the last run from the still; a vile substance that has never been utilized for any purpose, and is very little understood. It will be useful in the arts whenever we can remove its offensive odors and tarry consistency. For pharmaceutical purposes it cannot be made practical. Amorphous paraffin has never yet been produced from the tars of distillates. Complaints are made that amorphous paraffin is found once in a great while to act as an irritant. This is owing to faulty distillation; 180° F. is as high as ought to be used in the still. When allowed to run much higher, the particles of oil are scorched, developing creosote, which is an active irritant, and no one has been able to wash it out when once fixed in the paraffin. It has been suggested as an explanation of its irritating qualities, the imperfect burning of the animal charcoal. This cannot be the case. Bone is usually bought in large quantities of many tons at a time, enough to charge a great number of filters, which would be the means of putting on the market large quantities of an inferior article, whereas, on the contrary, it is very rare to have any complaint of the kind.

The question is often asked how best to perfume amorphous paraffin. To this it may be answered, use none other than the pure oils. With the common extracts or oils cut in spirits, you can have no success, as the spirits will not unite

with the amorphous paraffin. Attar of roses is best when used as a hair dressing.

Complaints are often made that the amorphous paraffin stains. This has been one of the most difficult problems to solve in petroleum, and one that has never been overcome by any one. Many have claimed that the staining properties have been removed. The staining property is charcoal held in solution, which, once impregnated in the fabric, has proved impossible to remove. Heat when used as in ironing brings out the stain, where before it was not perceptible.—*Oil, Paint and Drug Reporter.*

[Continued from Supplement No. 378, page 6031.]

MALARIA.

By James H. Salisbury, A.M., M.D.

Prize Essay of the Albany Medical College Alumni Association, Feb., 1882.

II.

PERIODICITY OF SYMPTOMS.

Another curious effect of poisonous fungi on the system is their tendency to produce remittent or intermittent symptoms—the tendency to periodicity. Christison tells us of a whole family, consisting of a woman and four children, who were attacked by a tertian fever by living exclusively for four months on edible mushrooms. The peculiar cause of the fever was made more manifest by the fact that the husband of the woman, who lived on other fare, escaped all disease; while a cutaneous eruption and subsequent gangrene of the extremities attacked finally those who had the fever. Westerhoff observed in those who were poisoned by mouldy food an intermittent somnolency, which he termed a remarkable feature of the case.

Mr. Gussang saw cases of ergotism, where the sensations either of heat or cold were intermittent.

A young woman who ate a dish of Agaricus clypeatus, and was attacked with nausea, vomiting, bilious stools, and a frequent pulse, had a marked remission on the fourth day. The patient was at ease throughout the night, the skin was moist, and the pulse better. The other symptoms all abated, and the patient slept.

On the fifth day the symptoms returned, with delirium, sighing, anxiety, failing pulse, great dyspnœa, partial yellowness of skin, and even a locked jaw, as in some cases of yellow fever.

A reverend gentleman of New York city, in 1845 went with his family to a place about three miles from the Hudson, near Sing Sing. It was selected because of its reputation for health and its exemption from malarial diseases. In August and September, when mushrooms were very abundant, and when the country people abstained from their use under the impression that they disposed them to fevers, the clergyman's lady, in her frequent drives, collected them daily, and for some time subsisted almost exclusively upon them. The remainder of the family ate them more sparingly and less frequently. About the end of September the lady was attacked by an irregular fever, without periodical chills but marked by an exacerbation on every second day. Thus the nature of the case was not suspected until the return of the attack in the spring, which became regularly periodical in June, and assumed a distinct tertian form. It was then readily cured by quinine and other intermittent remedies.

CRYPTOGAMS GROWING UPON THE ANIMAL BODY.

Caffort alleges that the Agaricus fimentarius is found in ill-conditioned wounds.—*Annal de Montpellier*, 1808.

Mery and Lemery cite cases where fungi grew on the skins of animals, even when not wounded or ulcerated.

Schoenlein and Remak observed, and Fuchs and Langenbuch confirmed the observation, that forms apparently vegetable, and of fungiform structure, rooted themselves in the skin of Porrigo favosa. Greeby subsequently determined that the crusts of Porrigo are almost entirely composed of the plants. The vegetable nature of the disease seems to be established by the transfer of it by inoculation to a phanerogamic plant, thus imparting to a vegetable a disease contagious in man.

More recently microscopists have detected vegetations in Porrigo lupinosa, Impetigo scrofulosa, serpiginous ulcers, Sycosis menti, and Porrigo decalvans.

The mucous membrane as well as the skin affords a nidus for cryptogamous growths—aphthæ.

Dr. Goodsir describes curious vegetable organisms developed in the stomach during indigestion. Mr. Greeby and Mr. Goodsir have both detected what they call fungoid cells in Pyer's glands in typhoid fever.

MUSCARDINE.

The Botrytis bossiano destroys silk worms.

Christison says that one of the greatest peculiarities of fungus poisons is the interval before attack, and the difference in that interval. M. Pauler, in his work on mushrooms (1812), says that the extract and alcoholic tincture, and even the juice of the Agaricus bulbosa and vernus, when given to dogs, did not make them sick in less than ten hours after their administration.

Christison mentions the poisoning of six persons by the Hypophyllum sanguineum, or toadstool, in Scotland, most of whom were attacked after the lapse of twelve hours, one after twenty hours, one after twenty-four hours, and the last in thirty hours.

Gmelin quotes seventeen cases which did not exhibit symptoms of intoxication until the expiration of a day and a half after the meal after which the poison was swallowed.

Corvisart's journal relates that of some soldiers who ate of the Agaricus muscarius, a part were attacked with gastric symptoms almost immediately, but that others were indisposed only after the lapse of more than six hours, of whom four died.

Malarial poisons do not seem to be transported usually for any great distance from the point of their origin. It is stated by authors entitled to credit that the wearing of a gauze veil, or the stretching of a gauze screen across an open window, adds much to the security of the wearer or the occupant of the chamber in even the most miasmatic localities. It is believed to be very unhealthy to sleep in damp mouldy sheets. The dust from old books that have been long packed away often excites coryza, and inflammation of the Schneiderian membrane, and local fever of throat and air passages.

There is abundant evidence that miasmatic poisons of certain kinds, as that of yellow fever, etc., may be transported for long distances in the trunks of clothing, in the holds of ships, etc. Dr. Rush mentions one trunk case in detail, and says that he heard of two other instances, in all of which only those suffered who opened the packages. According to William Stevens, of Santa Cruz, "the poison is made more intense by being confined in clothes and bedding."

In 1747, the trunk of a young supercargo, who died at Barbados, was opened in Philadelphia in the presence of Mr. Powell, Mr Halton, three Welshmen, a cooper, and a boy of Mr. Powell's; all sickened and died of yellow fever within a few days.

Hassack says: "I have seen the cases of some servants attacked by yellow fever, upon receiving the clothing of a relative who had died of that disease in the West Indies, at a time when there was no yellow fever in New York." He also further says that "after the death by yellow fever of the late Gardner Baker, while on a visit to Boston when it prevailed epidemically, his clothes were sent home to his wife, then a resident of Long Island. The opening of the trunk was followed by yellow fever, of which Mrs. B. died. No disease of the kind existed in New York or its vicinity at that time."

That the poison of yellow fever is thus transported, there can be no longer any doubt. It is only thus that we can comprehend how a perfectly healthy crew may bring with them, in the close hold of their ship, the germs of disease, which after their dismissal may pestilentially affect the stevedores who discharge her, or only the laborers who disturb the ballast. We can thus explain the usual pause between the first set of cases caught by visitors to, or laborers on board the ship, and the attack upon the inhabitants of the vicinity. This curious interval, noticed by almost every writer, occupies from about ten to fifteen days, while the period of incubation after exposure to a known source of infection is only about five days. (Vachi.) This interval is only to be explained by the supposition that germs of some kind have gained a footing on shore, have grown, and become more numerous. It is the crop in the hold which produces the first set of cases. It is the crop on land that causes the second.

Different fungi affect different animal organisms differently. The Agaricus clypeatus of the west of Europe poisons in one way, the Amanita muscarius of Siberia in another. One irritates, and the other intoxicates.

So a certain kind of mucor produces dysentery, another typhoid symptoms, and a third excessive vomiting. The ergot of rye excites formication, fever, and sphacelation; the ergot of maize, fever, loss of hair and nails, etc.

So far as known, the effects produced by the introduction of poisonous cryptogams into the system are interesting and peculiar. In most cases no abnormal symptoms present themselves for some little time after the reception into the body.

This dormant period may be called the incubative period. After this period, which may be longer or shorter, a train of abnormal symptoms are ushered in, which are of a febrile character. These are sometimes continued, sometimes remittent, and at other times intermittent. These are always accompanied by abnormal conditions of the epithelial tissues. Sometimes the epithelial derangements are confined to the glandular tissues internally, and at others it is confined to the cutaneous and mucous surfaces. The same cryptogamic poison always produces the same or similar abnormal states. The eating of mouldy food, such as meat, pies, bread and cheese, has been known to produce severe sickness and even death. The symptoms, so far as noted, are those of a febrile character, often preceded or accompanied by algid symptoms. The Agaricus muscarius produces, after an interval, rigors followed by a train of symptoms resembling febrile intoxication.

In diphtheria I have found the mycelium of a mucor resembling somewhat the Perinospora infestans, growing in the exudations, and in the subjacent epithelial tissues. I have called this the mucor malignans.

In a lengthy series of experiments connected with the cause and prevention of camp measles, published in the July number of the *American Journal of the Medical Sciences* of 1862, there appeared the strongest evidence for the belief that the minute cryptogams growing upon old straw under certain states of the atmosphere, and under peculiar circumstances, may produce measles, etc. In erysipelas, so far as my investigations have gone, there appears to be developing in the capillary vessels of the parts affected the mycelium of a beautiful species of penicillium. The developing mycelium clogs up the capillary vessels, and the tumefaction and redness keep pace with the extending filaments of the fungus. It requires much care and experience in microscopic manipulations, as well as a thorough knowledge of the appearance of fungoid filaments developing in animal tissues, to determine the presence of fungoid mycelium in the blood of the capillary vessels in erysipelas.

Inexperience and the want of knowledge of these organic forms subject one to constant error. Such observations require time, patience, and skill.

In the early settlement of Ohio and other portions of the Western country, there appeared a disease known as the "wheat sickness." The eating of the flour of wheat from certain localities would always produce rigors, febrile symptoms, nausea, and vomiting. The wheat from which such flour was made always had a small reddish spot about the size of the head of a pin situated on the chit. There is no doubt that this was a fungus developing in the grain.

In certain glycogenic states of the system a species of Penicillium (Torula) develops in the secretions of the mucous membranes so rapidly that a white curdy crust is formed on the tongue, throat, fauces, œsophagus, and sometimes dips down into the trachea. This growth resembles the diphtheritic exudation, and is usually taken for such. The microscope readily settles this question. This growth is very apt to occur in low states of the system in all such as feed too exclusively upon farinaceous and saccharine food. Such patients are subject to flatulence, prickling, or paralytic sensations in hands, feet, and legs, with a mixed up, confused feeling in the head, a partial loss of memory, etc. Exhausting diarrhœa frequently follows, which often proves fatal. In these states the patients are frequently affected with rigors, small pulse, and great anxiety, followed by febrile symptoms. The use of rye containing a parasitic fungus often results in febrile symptoms, accompanied and followed by a congestive state of the capillary vessels, which frequently results in gangrene of the extremities, etc. Similar symptoms have been observed from the use of diseased wheat.

The above is deemed sufficient to show the cryptogamic tendencies of modern writers, of whom the late Dr. Mitchell, of Philadelphia, stands the most prominent. Dr. Drake, of Cincinnati, published a paper on this subject about the same time, in which he advanced about the same views without any knowledge of Prof. Mitchell's publication. Further on we shall allude to the researches of still later times.

We now proceed to the subject proper of this paper, a brief description of a series of investigations connected with the cause of intermittent fever. What I have to say may be embraced under two heads:

First: The investigations connected with the sputa, the urine, the blood, the sweat of persons suffering under what is called intermittent fever.

Second: The investigations connected with the bodies suspended in the night air of the malarious levels, and inhaled; and also the investigations connected with the study of the soils of malarious districts. These divisions may become somewhat mixed in the account, from natural causes; still I shall try to be as explicit as possible.

HOW THE OBSERVATIONS CAME TO BE MADE.

During a lengthy series of careful experiments, connected with camp diseases and those affecting vegetation, as the curl in peach leaves and the blight in apple, pear, and quince trees, etc., and in studying the causes and consequences of fermentation, gangrene, decay, and the changes going on in diseased tissues, I was led by some of the experiments connected with bodies suspended in the atmosphere in the direction of causes of fevers, and especially those of an intermittent type.

Intermittent fever began to show itself in the rich, malarial districts of the Ohio and Mississippi valleys in 1862, during the month of May. It did not, however, prevail to any great extent till the months of July and August. The weather had been unusually damp up to about the first of July. During the months of July, August, and September there was scarcely any rain. Springs and streams became very low; swamps and humid grounds became dry; vegetation almost entirely ceased to grow, and the country presented all the signs of a severe drought. The disease, which became quite general during the month of July in ague districts, increased rapidly till about the 20th of August, when, in the vicinity of places above named, the disease had invaded nearly every family.

The examinations connected with this inquiry were begun during the month of June. Through the kindness of Drs. Boestler and Effinger and several other friends, I obtained, for microscopical examination, blood, urine, sweat, and sputa from numerous patients laboring under various types of the disease.

The blood was drawn either just before the chill, during it, during the febrile stage, or the period of sweating.

The urine was obtained at all stages of the paroxysm and during the interval.

Sputa Examination.—My first step was to examine microscopically the sputa of those laboring under intermittent fever, and exposed during the evening, night, and morning to the cool, heavy vapors rising from stagnant pools and low, humid grounds. The morning sputa was that used. In this sputa occurred uniformly, and usually in considerable abundance, minute oblong cells, either single or aggregated, and with them a variety of other large cells, mostly algæ, but none of which were so abundant and uniformly present as the peculiar, minute, oblong cells just mentioned.

SEARCH TO FIND OUT WHERE THESE CELLS CAME FROM.

I began suspending rectangular plates of glass, 16 by 22 inches, about one foot above the surface of stagnant pools and marshy grounds that were partially submerged. The plates were placed horizontally, each resting on four pegs, a single peg supporting each corner of a plate. The plates were placed in position at dusk, and secured in the morning before sunrise. Invariably the under surface of the plates would be covered thickly with large drops of water. This condensed vapor was subjected to careful microscopical examinations. I found many of the unicellular algæ that I had previously found in the sputa above named. But the oblong algæ so uniformly present in the sputa were rare. I repeated these experiments for many nights, varying widely the localities, with the same results.

In going to the stagnant pools and swampy grounds southeast of the city of Lancaster, Ohio, to suspend the glass plates, I had to pass over a rich, peaty, prairie bog, where the water had become mostly dried off, and the surface broken by the tread of cattle. I had noticed that in walking over this ground a peculiar, dry, feverish sensation was always produced in the throat and fauces, often extending to the pulmonary mucous surfaces; and that my sputa was, after returning, uniformly filled with minute, oblong cells, above described. This drew my attention to the partially desiccated, peaty bog, where the surface had been broken by the tread of cattle. I discovered on the recently exposed earth what appeared to be a whitish mould, or more closely the incrustation of some salts.

I here suspended the plates of glass, and the following morning, much to my delight, found the inferior surface of the plates covered with the minute unicellular algæ which I was in pursuit of. I immediately returned to the bog and secured samples of fresh earth that were covered with the incrustation and some that were not, and also portions of the boggy turf. On placing a fragment of the incrustation under the microscope, it was at once discovered to be made up of aggregated masses of the minute unicellular algæ so uniformly met with in the sputa of those exposed to the influence of cool vapors of the ague districts. It was further seen that there were several species of palmellæ, and that the larger ones were infested with parasitic fungi.

The locality from which these first results were obtained is situated on the southeast side of the city of Lancaster, Ohio, between the canal and railroad, just east of the starch factory.

Here stretches out to the southeast along the canal, a low, peaty, prairie bog (and in its vicinity the grounds are low and humid), containing from seventy-five to one hundred acres. The portion of the town (3d ward) adjoining this bog is all of it situated below the line about thirty five feet above the bog; has always been a fertile field for intermittents. Those living immediately on the edge of the bog are frequently subjects of ague yearly, from May to November. August and September are usually the worst months.

Having progressed so far with the experiments, and having arrived at results which appeared to throw some light upon the cause of intermittent fevers, I continued the investigations with renewed zeal.

MODE OF COLLECTING BODIES IN THE AIR ELEVATED BY THE NIGHT VAPORS.

A glass screen standing perpendicularly, and in front of it a large funnel with a broad open end pointing from the screen and the small end terminating within one-half inch of it.

This was arranged on a pivot so constructed that the force of the currents of air kept the broad mouth of the funnel toward the wind. When an observation was to be made, the screen was covered with glycerine and the apparatus suspended at the desired height, and left for one or two hours.

The wind passing through the funnel and falling upon the coating of glycerine would deposit the small particles upon the smeared, suspended screen, while the air would pass out at either side. This was my "*aspirator.*"

On examining under the microscope the glycerine on the screen after an hour's suspension, all the bodies floating in the atmosphere would naturally be expected to be found in it.

By suspending the aspirator at different heights above the low, ague lands, at all hours of the day and night, the following facts were ascertained :

1st. That cryptogamic and other minute organic bodies are mainly elevated above the surface during the night. That they rise and are suspended in the cold, damp exhalations from the soil after the sun has set ; and that they fall again to the earth soon after the sun rises.

2d. That in the latitude of Ohio these bodies seldom rise above from thirty to sixty feet over the low lands. That in the northern and central portions of the State they rise from thirty five to forty-five feet, while in the southern from forty to sixty feet.

3d. That at Nashville, Tenn., and Memphis, and farther south, they rise from sixty to one hundred and more feet above the surface.

4th. That above the summit plains of the cool night soil exhalations these bodies do not rise, and intermittents do not extend.

5th. That the day air of malarious districts is quite free from these palmellæ and from causes that produce intermittents.

[*To be continued.*]

SAID I TO MYSELF.*

WHEN I was a nascent professional man,
 Said I to myself, said I,
An Institute member I'll be if I can,
 Said I to myself, said I.
For membership there is an honor indeed;
To the meetings I'll go with long papers to read,
And I'll do what I can when it comes to a feed,
 Said I to myself, said I.

I'll never throw dust in a stockholder's eyes,
 Said I to myself, said I;
Nor hoodwink an expert who's not overwise,
 Said I to myself, said I.
If I'm working a mine and the ore "peters out,"
Or its future is somewhat a matter of doubt,
I'll tell everybody they'd better keep out,
 Said I to myself, said I.

If I'm running a blast-furnace, little or big,
 Said I to myself, said I,
I'll not count my cinder as Bessemer pig,
 Said I to myself, said I.
My worthy profession I'll never disgrace,
By claiming of phosphorus only a trace,
When analysis shows that it isn't the case,
 Said I to myself, said I.

If I work as a chemist in iron and steel,
 Said I to myself, said I,
I'll never deceive, by a very great deal,
 Said I to myself, said I.
I won't say that silicon vainly I've sought;
That sulphur, if present, declines to be caught,
Nor put down for manganese decimal naught,
 Said I to myself, said I.

If as a geologist fortune I seek,
 Said I to myself, said I,
I'll try to avoid being bashful and meek,
 Said I to myself, said I;
For many geologists fail of success
Because they lack courage their views to confess,
And fear to offend if their thoughts they express,
 Said I to myself, said I.

If some well-endowed college of science and art,
 Said I to myself, said I,
As a learned professor should give me a start,
 Said I to myself, said I,
I'll try to know something of what I'm to do;
I'll read up on subjects relating thereto,
And besides teaching science, I'll study it, too,
 Said I to myself, said I.

In other professions in which men succeed,
 Said I to myself, said I,
Of "cheek" and assurance they often have need,
 Said I to myself, said I.
Professional modesty's pushed to excess;
The value of confidence all must confess,
And even E Ms need a little, I guess,
 Said I to myself, said I.

STATISTICS OF BEER CONSUMPTION.

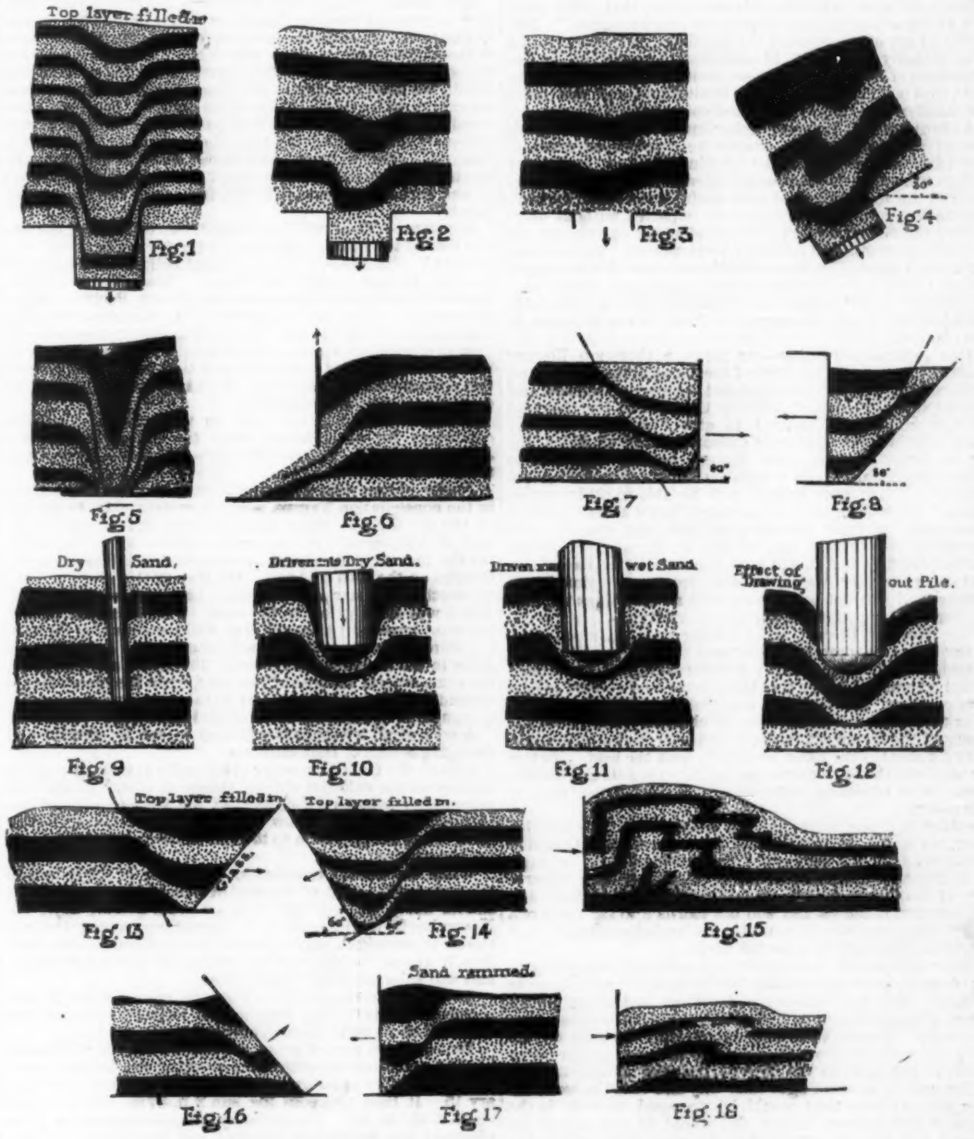
FROM statistics which have been recently compiled by the officials of the United States Internal Revenue Department, it appears that during the year 1881, 96,000,000 gallons of beer were consumed in this country, and 780,000,000 on the Continent of Europe and in Great Britain and Ireland. The total value of this beer may be computed at not less than $250,000,000 ; and of the whole quantity England, Scotland, and Ireland used as much as 282,000,000 gallons, or nearly one-third, the population drinking at the rate of about eight and a half gallons each per annum. In Germany 246,000,000 gallons were consumed, at the rate of some five and a half gallons per head. The United States stand third on the list, the average being about two and a half gallons for each inhabitant. The consumption in Austria amounted to 72,000,000 gallons or at the rate of two gallons per head. Belgium, considering the number of its inhabitants, drinks more beer than any other nation in the world. Her people swallow, upon the average, nine gallons of beer each per annum, and the total amount used last year in the country was 48,000,000 gallons. France consumes exactly the same quantity, but her population being six times that of Belgium, each of her inhabitants drinks only about one and one half gallons. France in fact, drinks less beer per head than any other of the great nations. Russia, which consumed only 1,800,000 gallons, alone excepted. Even in Denmark, the consumption is at the rate of three and a half gallons per head. The sum spent for beer in 1881 by the various countries may be roughly computed as follows: Great Britain, $72,000,000 ; Germany, $65,000,000 ; United States, $26,000,000 ; Austria, $20,000,000 ; Belgium, $14 000,000 ; France, $14,000,000; and Russia, $500,000. The Belgian, therefore, may be considered as the greatest beer-drinker ; and this is as it should be, for Belgium is the home of the modern system of brewing. It should be borne in mind, however, that little since beer, comparatively speaking, is consumed in Scotland and Ireland, where whisky is the "national" beverage, England, if taken without them, still maintains her old pre-eminence, John Bull's family drinking, probably, at the rate of at least ten gallons per head per annum.

* Lines read by Mr. J. C. Bayles at the Subscription Dinner, given by members of the American Institute of Mining Engineers at the Hotel Brunswick, Boston, February 22, 1883.

A STUDY OF THE MOVEMENT OF SAND.

IN the January number of the "Journal of the Austrian Society of Engineers and Architects," of Vienna, a paper is given by Ph. Forchheimer on "The Pressure and Movement of Sand." The author makes but few deductions from his experiments, but we produce the more important of his illustrations and the methods he used, in the hope that they may be as instructive to our readers as they are novel and suggestive.

The materials used in these experiments were clean wire sand, fine shot, and very fine "iron sand," such as was formerly used for blotting purposes. These materials were selected as representing a variety of angles of repose and differing in specific gravity. Only one of the above named materials was used at a time in making any single experiment. In the illustrations given, sand alone was used, arranged in layers of contrasting colors, so that the interior movement could be better observed and noted.



A STUDY OF THE MOVEMENT OF SAND.

In Figs. 1, 2, and 3, the author's experiments were in the direction of illustrating the effect of a sinking foundation. The sand was dry, and, as plainly shown in Fig. 1, the mass over the sinking portion assumes the shape of that moving portion; in this case it is a vertical cylinder. Figs. 2 and 3 show that the distance through which each layer sinks decreases as they approach the surface, and, as in Fig. 3, with only a slight settlement at the bottom, the top layer remains unchanged. When wet sand was used, the sinking portion became a cone with apex uppermost, instead of a cylinder as in the experiment Fig. 1. Fig. 4 shows that the movement of the sand is vertical, even though the plane of the shifting foundation lie at an angle with the horizon. Fig. 5 is a case where dry sand is allowed to run out of a bottom opening for a few moments. Fig. 6 shows the deformation of the layers when a side opening is made at the bottom. Figs. 7 and 8 represent the effect of moving a wall horizontally outward, whether the wall has a vertical or inclined surface.

Figs. 9 and 10 show the disturbing effect upon the sand layers of piles driven into dry sand, Fig. 11 the same in wet sand, and Fig. 12 the result of drawing out a pile from dry sand.

The remaining figures relate to the movement of confining walls in different directions and to different degrees. Fig. 13 is an inclined vall moved horizontally, and away from the sand. Fig. 14 is an inclined wall shifting outward and downward at an angle of 30° with the horizon. Fig. 16 is a wall moved outward and upward at an angle of 40°. Fig. 17 is the sand in movement, as Fig. 7, but in the first figure the sand was compacted by ramming. Figs. 15 and 18 show the effect of pressing a vertical wall against dry sand, the movement in Fig. 15 being six times greater than in Fig. 18. It will be noticed that in neither of the latter cases does the plane upon which the sand moves pass through the foot of the vertical wall.

To fix the sand layers in any required position, in the course of his experiments, the author used melted paraffine, and was thus enabled to saw the consolidated mass in any desired plane, and study at his leisure the direction taken by any single layer. In the experiment recorded, as in "wet sand," the same result was obtained by making the trial while the paraffine was still hot and liquid; water was not used.—*Engineering News.*

A LAND SINK.

REELFOOT LAKE, a noted body of water situated along the line which divides Tennessee from Kentucky, was formed by the mighty earthquake which shook the valley of the lower Mississippi in 1811. Tradition has it that during that terrible convulsion of nature the water in the Mississippi temporarily flowed up stream. The course of the great river was changed for miles, and in certain localities the entire topography of the country was altered. Where Reelfoot Lake is now once stood a heavy forest. The earthquake caused this land to sink to the depth of many feet, and it is now covered with a body of water nearly forty miles in length and more than a mile in width at certain places. Even to this day the hunter or fisherman paddling over its pellucid depths can see, far below, the tops of the great trees, which once towered up into the air.

About 1:30 on the morning of January 11 quite a severe shock of an earthquake was felt all through this section of the country. It was particularly severe in the neighborhood of Reelfoot, and the land in that vicinity commenced sinking again. A reporter for the *News* met last evening Mr. R. A. Browder, of Fulton, who states that the rumors which have been current here for several days concerning terrestrial disturbances in the locality described are true, though the trouble was not as serious as was thought at first. Many changes are said to have taken place along the banks of the Reelfoot. In Lake County, Tennessee, a gentleman named Wade, who lived between the lake and the hills, lost his entire farm of more than one hundred acres. The shock of the 11th awoke both himself and family. It was so severe that all of them fled from the house to the bluffs in the rear for safety. Only a short distance from his residence they came across a huge crack or fissure in the earth some ten feet wide. They had no means of ascertaining its depth in the darkness, and Mr. Wade and his sons returned to the house and secured planks, which they threw over it as a temporary bridge. In the morning the opening was discovered to be from fifteen to twenty feet in depth. The earthquake had sunk all the ground from the lake shore nearly up to the house, and also, by a peculiar freak, thrown

this huge crack quite around the premises, and swallowed up the road. With the exception of a little spot on which the house stands, the whole of Mr. Wade's farm is now permanently added to the lake and is covered with water. Between 400 and 500 acres of adjacent land are also submerged.

Not far from Mr. Wade's place at the time of the occurrence of the phenomenon, a party of hunters were encamped. They were awakened by the shock, and compelled to abandon all their camp equipage and flee for their lives, the water came upon them so rapidly. They were also stopped by the sudden opening in the ground, and hurriedly threw a narrow bridge of fence rails across it. The newly sunken land lies on the east side of the lake. The fissure extends for a long distance just at the foot the bluff, and varies considerably in width and depth—*Paducah* (*Ky.*) *News.*

"SCHOOLED, BUT NOT EDUCATED."

To the Editor of the Scientific American:

Under the above heading we find in your issue of March 10 some remarks on education which, though partly very true and appropriate, we think might lead to serious misunderstanding.

Were the speaker (his name is not given) not represented as a "shrewd observer," a "rarely capable business man," etc., we might have let his views pass for what they are worth, but, being sealed with such authority, we think they should not go altogether unnoticed.

We fully agree with the able gentleman that "the great lack of our country to-day is properly educated men." The universal cry of the country is education. But how are men to be properly educated? If education consisted in the development of business cleverness alone, it might be said with truth that our great educational institutions, and still more our smaller ones, are in grasp and spirit far behind the age. But education has other and higher functions. Not to speak here of religious training—which we consider an essential part of education—the object of education, particularly of college education, is prominently mental discipline, and secondarily the acquirement of such useful knowledge, literary, speculative, and positive, as can be imparted without overtasking the mental powers of the student, or obstructing his intellectual, moral, and religious development. Professional studies and specialties lie outside the range of this more general and, as it were, preparatory education, and must needs presuppose it, if it should not degenerate into a lamentable onesidedness, which, we regret to think, is too common in this country.

This general education—we mean a thorough literary training through the medium of the classical languages, and a systematic, compact, but complete course of science and philosophy—far from "unfitting the student for practical life" is eminently calculated to give him that "broader grasp of principles and larger executive ability" which our age so much requires, even though he may have still to learn a good deal in the "rude and costly school of experience." A man thus trained will be able to utilize experience. He will be able to compare fact with fact, reduce phenomena to their general principles and causes, form analogical conclusions, and clearly see his way, where the undisciplined specialist will have to grope in the dark. He will have broader views, be free from professional prejudices, and will not be likely to look at all things through the narrow perspective of his own specialty.

Nor does this literary and scientific training impede, but rather forwards practical cleverness. As a proof of this statement I will only refer to the trite saying of the world-famed chemist Liebig: that those boys who entered his laboratory from the German Real-Schule (business school), from their practical knowledge of chemistry, surpassed the pupils of the Gymnasia (classical schools) at the outset, but after six months the latter invariably took the lead. To this we may add that it requires but slight experience in the department of education to become convinced of the truth of this assertion.

Should any one, however, not share our views on this point, we would respectfully beg him to remember that man has higher aims and aspirations than business stock or capital; and to cultivate, chasten, and develop those higher yearnings of man's nature is the main function of education, and this function it cannot and will not sacrifice to the spirit of a materialistic age, else it would cease to be education, and would have no right to wear the name.

Those who would have their boys educated according to the *ideal* of your businesslike friend need not send them to colleges. The best education for them, according to his views, we may infer, would be, after the necessary elementary instruction, to make them pass successively through all the phases of business, from the common shop-boy or the shoeblack, if you will, to the highest financial administration, taking care to let them fight their way and face the world as they find it; thus they would be prepared to walk in the shoes of their pioneer fathers, and would be relieved of the necessity of procuring their education against the will and in spite of their teachers.

But it must be remembered that there are millions in this country, of every and of no religious denomination, who believe in the higher functions of education—who believe that a Daniel Webster, a Washington Irving, a Longfellow, and other cultured geniuses have added more glory to their country than have our modern capitalists, and to these the friends of true education look for support and patronage.

However, your financial friend, on his part, may be satisfied that not a few Americans will follow his line, and that, in any case, his country will not be behind the age in business smartness.

Meanwhile, let the many students of colleges who, with deserved interest and no slight profit, read the SCIENTIFIC AMERICAN, rest assured that a real and thorough classical and scientific training, which should be given in all colleges and is given in some, does not unfit, but eminently qualifies them for a glorious future in whatsoever department of life.

X.

RATTLESNAKE POISON.

By H. H. CROFT.

A FAVORITE antidote for rattlesnake poison, in Mexico, is a strong solution of iodine in potassium iodide. The author has tested some of the poison itself with this solution, and finds that a light brown amorphous precipitate is formed, the insolubility of which explains the beneficial action of the antidote. When iodine cannot be readily obtained, a solution of potassium iodide, to which a few drops of ferric chloride has been added, can perhaps be used as an antidote to snake poison; it is a very convenient test for alkaloids.—*Chem. News.*

ASTRONOMY FOR 1883.*

WE will sketch a few of the principal celestial phenomena which the terrestrial and planetary motions will bring to our observation during the year 1883.

THE SUN.—We are now in the period of maximum spots. Since 1878, the year of minimum, the number of solar spots has gradually increased. It is as a tide, the cause of which is unknown. Every eleven years there is a maximum, and every eleven years a minimum. There have been previous maxima in 1848, 1860, and 1871; and minima in 1855, 1867, and 1878. The number of spots increases for about three years and seven months, then the tide runs down for seven years and a half. The year 1883 will be, as 1882, a very favorable epoch for the observation and study of these spots.

Powerful instruments are not necessary to see these curious phenomena. A small spy glass will often suffice. It is necessary to protect the eye by a piece of dark glass in order not to be blinded by the sun. Sometimes the spots are large enough to be visible to the naked eye; among these may be mentioned those of April 17, May 14, October 2 and 27, and November 17 last. It is interesting that at these dates there were magnificent auroras and great disturbances of the telegraphic lines. Our planet is connected with the sun by a secret sympathy.

The sun is also the scene of gigantic explosions which are now at their period of recurrence. But these can be seen only with the aid of a telescope.

We may expect to see this year more of these beautiful auroras.

THE MOON.—The surface of the moon does not vary from year to year; at least the changes which it undergoes are not visible to those assiduous observers who give their whole time to the study of our satellite. Our readers know that in order to show the topography and geography of this neighboring world, we must not choose the time of full moon, for then we cannot judge of the reliefs of its surface. But during the evenings which precede the first quarter, the moon is placed obliquely relatively to the sun, the mountains throw their shadows a great distance, and we can know at first sight the singular configuration of the world which is the nearest to us and perhaps the most different from us of the whole solar family.

ECLIPSES.—There will be, in 1883, two eclipses of the sun and two of the moon. (Three of these are not especially important.) The second will be a total eclipse of the sun of May 6. It lasts nearly six minutes. The line of totality passes through certain islands of the South Pacific. Many astronomers will set out to observe it. At the time of the total solar eclipse of May 17 last, observed in Egypt, they believed they saw traces of a lunar atmosphere. It is principally to verify this important indication that they propose to observe this eclipse with especial care. It will be extremely valuable on account of its long duration.

PLANETS.—We can this year, in the order of favorable conditions for observations, class the planets as follows: Jupiter—Saturn—Venus—Mercury—Uranus—Mars—Neptune.

Jupiter shines with great splendor during the whole night in the constellation Taurus, near its eastern side, to the left of the star Zeta of the third magnitude, and 17° east-north-east of Aldebaran. It retrogrades, approaching Aldebaran, till the 15th of February, then turns to the east and reaches Gemini on the 30th of April. On May 22 it will pass about 50' south of the star μ Geminorum, of the third magnitude. But it will then be low in the west. This beautiful planet, the most important of our system, will remain under the horizon during the summer, and will return again in October to shine in the constellation Cancer. There are, a month later, the same aspects as those of last year, since the planet moves around the sun in twelve years; so that every one can readily recognize it, at least, by its unrivaled brilliancy.

A very small telescope is sufficient to see its elegant and changing *cortége* of four satellites.

Saturn, the greatest wonder of the solar system, preceding Jupiter on the celestial sphere, shines as a star of the first magnitude, without twinkling, at the western side of the constellation Taurus, below the Pleiades. On November 14, 1882, it was in opposition to the sun in the favorable position for observation.

While the annual retardation of Jupiter is thirty-two to thirty-five days, that of Saturn, of which the revolution is almost thirty years, is only thirteen and a quarter days. On November 28 it will again be in opposition, passing the meridian at midnight, and will be at its approach to the earth. It will appear in the east in September above Aldebaran, and will shine on us till April, 1884.

Its wonderful rings will continue to open for us in perspective. In 1877 they presented to us their edge; in 1885 they will show their greatest opening.

Venus, which passed across the sun on the 6th of December last, and since has shone as a morning star in the eastern heavens, arrives at its greatest western elongation on February 15. It then precedes the sun 2 h. 37 m. and is distant from it 46° 50' 14". Its phases are the counterpart of those observed last September, October, and November. Its crescent, always on the side next the sun, goes on enlarging. It departs from us, being visible in the morning till August 25, and then can be seen on the other side of the sun on the 28th of September, after which it is visible in the evening.

Mercury continues its rapid oscillations from one side to the other of the sun.

Its times of visibility, as calculated by M. Vimont, are:

January 21,	the planet	sets	1 h. 42 m.	after	the sun.
March 3,	"	rises	0 57	before	"
May 21,	"	sets	2 9	after	"
July 10,	"	rises	1 21	before	"
August 28,	"	sets	0 41	after	"
October 22,	"	rises	1 46	before	"

These figures show the extremely rare fact of a difference of about 2 h. 9 m. between Mercury and the Sun. The time from April 28 to May 26 will be particularly favorable for observations of this planet, which we can recognize in the twilight by its bright golden splendor, reminding us of the nature of the solar rays, in which it remains constantly bathed.

Uranus probably cannot be found in the heavens without the aid of a chart, its brightness slightly surpassing a star of the sixth magnitude, and it is necessary to know well its position to find it. We derive especial interest in observing it when we remember that Sir William Herschel, when he discovered it in 1784, extended the frontiers of the system from 886 to 1,782 millions of miles. It moves very slowly, since its revolution around the sun requires no less than 84 years to complete it, and its disk becomes visible only in a telescope of some power. It is in the constellation Leo, which is over head at night from January to July. It is in opposition to the sun, passing the meridian at midnight on March 11.

Mars.—The most interesting of all the planets, on account of the progress made in the last few years in a knowledge of its conditions of habitability. The planet Mars is now out of our easy sight. It passed the sun on the 10th of last December, moving slowly, and is at right angles to him on October 31 next. During the last months of the year it may be observed.

Neptune is, for observation, the least interesting of all the planets. Yet we like to see it at least once in our life, because it marks the frontiers of the system, is more than 2,700 million miles from us, and because its discovery in 1846, due to the genius of Leverrier, has been the crown of the mathematician. A special chart is yet more necessary than for Uranus, for its pale light does not surpass that of a star of the eighth magnitude. It moves among the stars very slowly, its turn of the heavens requiring almost 165 years to accomplish. It is eighty-five times larger than our earth.

Such are the principal aspects of the heavens for the year which opens before us. We have not spoken of the stars, for their study can be considered as constant and regular, and the same year by year. The comets, on the contrary, arrive in general without our knowledge, and seem to insinuate themselves as *fugues* in the celestial harmony. Our design in this general sketch is only to outline the great features of the tableau.

* Translated and abridged from *L'Astronomie.*

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